3.11 Noise and Vibration

This section summarizes the guidelines and standards for evaluating noise and vibration impacts, existing noise levels, the long-term and temporary noise and vibration levels from the No-Build Alternative and the proposed Modified Locally Preferred Alternative (LPA), and mitigation measures for noise and vibration impacts. The information presented in this section is based on the Noise and Vibration Technical Report (as listed in Appendix H). Section 3.16, Ecosystems, provides information about potential noise-related effects on fish and wildlife.

The assessment of reasonably foreseeable effects in this section is based upon the noise and vibration study area, defined in Section 3.11.2, and the temporal proximity parameters detailed in the Chapter 3 introduction.

How do decibels relate to sound levels?

The human ear generally cannot detect very slight changes in noise levels. The smallest change in noise level that a human ear can perceive is about 3 decibels, while increases of 5 decibels or more are clearly noticeable. For most people, a 10-decibel increase in noise levels is perceived as a doubling of sound level.

3.11.1 Changes or New Information Since 2013

The Columbia River Crossing (CRC) Selected Alternative identified in the 2011 Record of Decision (ROD), as revised by the 2012 and 2013 re-evaluations, is referred to as the CRC LPA. Over the past 10+ years since the CRC LPA was identified, the physical environment near the Interstate Bridge, community priorities, and regulations have changed, which necessitated design revisions and resulted in the proposed IBR Program Modified LPA (see Section 2.5.2). Evaluation of potential impacts associated with noise and vibration has been updated in this Final SEIS to include:

- Updated existing noise measurements for traffic noise modeling and transit noise assessment.
- Updated all peak-hour and peak-truck-hour traffic data for traffic noise assessment.
- Updated all transit operation assumptions for transit noise and vibration assessment.
- Updated the locations of sensitive noise receptors based on changes in land use.
- New FHWA, WSDOT, and ODOT traffic noise assessment guidance and FTA noise and vibration guidance.
- Developed new traffic noise model and transit noise and vibration assessment models.
- Changes to the project footprint, as necessitated by changed conditions, and in existing land uses resulting in changes to proximity to sensitive receptors.
- Compared to CRC, an additional 267 sensitive sites were modeled within the IBR Program noise and vibration study area.

3.11.2 Existing Conditions

Understanding Sound

How Sound Levels Are Measured

Two aspects of sound that partially determine its impacts are loudness and frequency. The loudness of sound is a result of its energy, which is measured in decibels (dB); an A-weighted decibel (dBA) measures noise as perceived by the human ear.

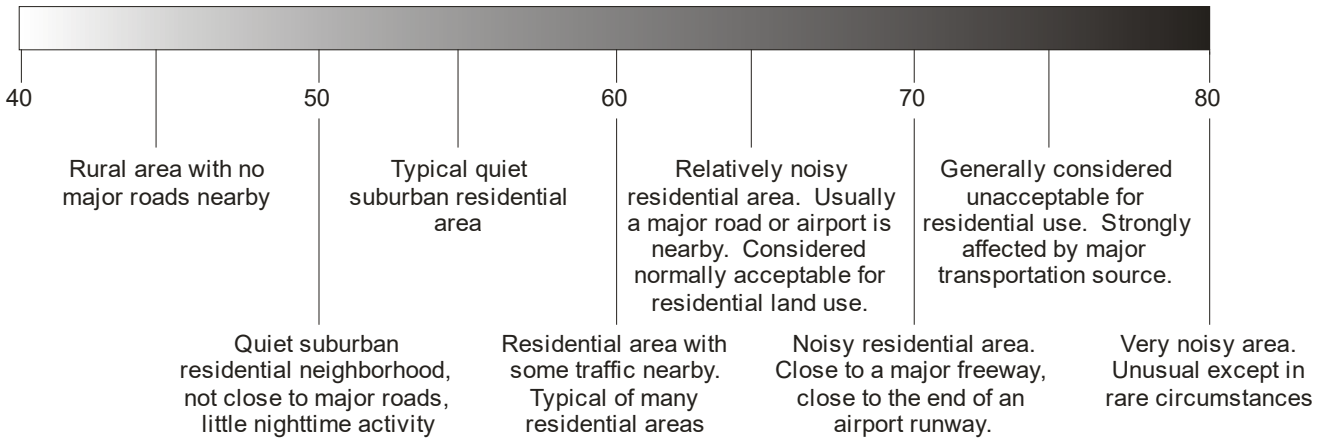
Most noise levels at a given location vary over time. To account for this variation, a commonly used noise measurement is the equivalent sound pressure level (L_{eq}). This noise analysis uses L_{eq} to describe traffic and transit noise at schools, libraries, and other noise-sensitive institutional uses. Consistent with FTA noise regulations, this analysis also gives more weight to noise that occurs at night (from 10:00 p.m. to 7 a.m.). This method produces the *day-night equivalent sound level*, which is abbreviated as L_{dn}.

Section 2.4 of the Noise and Vibration Technical Report (as listed in Appendix H) provides detailed methods for sound level monitoring and noise model development.

Typical Noise Levels

Figure 3.11-1 shows typical community noise levels. Figure 3.11-2 shows how some common noise sources are perceived by the human ear.

Figure 3.11-1. Typical Community Noise Levels (in L_{dn})



Source: FTA 1995
L_{dn} = day-night equivalent sound level

Figure 3.11-2. Typical Noise Source and Human Perception of Sound Levels

Noise Source or Activity	Sound Level (dBA)	Subjective Impression	Relative Loudness (human judgment of different sound levels)
Jet aircraft takeoff from carrier (50 feet)	140	Threshold of pain	64 times as loud
50 horse power siren (100 feet)	130		32 times as loud
Loud rock concert near stage, Jet takeoff (200 feet)	120	Uncomfortably loud	16 times as loud
Float plane takeoff (100 feet)	110		8 times as loud
Jet takeoff (2,000 feet)	100	Very loud	4 times as loud
Heavy truck or motorcycle (25 feet)	90		2 times as loud
Garbage disposal (2 feet)	80	Moderately loud	Reference loudness
Typical at-grade light rail vehicle	70		½ as loud
Moderately busy department store	60		1/4 as loud
Typical televison show (10 feet)			
Typical quiet office environment	50		1/8 as loud
Bedroom or quiet living room	40	Quiet	1/16 as loud
Quiet library, soft whisper (15 feet)	30	Very quiet	1/32 as loud
High quality recording studio	20	Just audible	1/64 as loud
Acoustic Test Chamber	10		1/128 as loud
	0	Threshold of hearing	

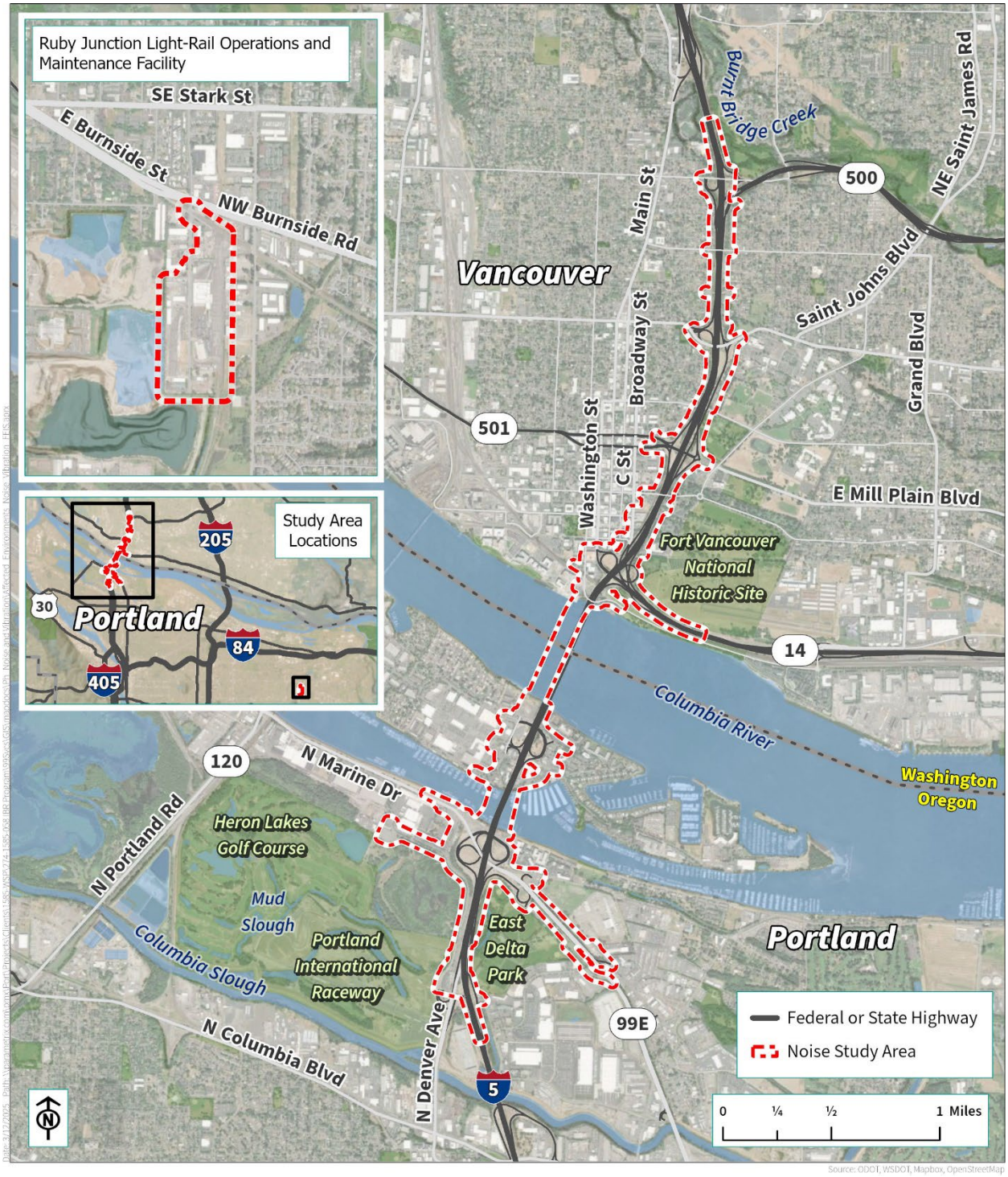
Sources: Beranek (1988) and U.S. EPA (1971).

Noise Criteria and Analysis Methods

Data Collection Methods

The noise and vibration study area for the Modified LPA includes a 5-mile segment of I-5, approximately between the SR 500 interchange in Washington and the I-5/Columbia Boulevard interchange in Oregon, and the area around TriMet's existing Ruby Junction Light-Rail Operations and Maintenance Facility (OMF) in Gresham, Oregon (Figure 3.11-3). This noise and vibration study area includes temporary construction easements established directly adjacent to the proposed construction areas, staging areas and casting yards, and potential park and rides in downtown Vancouver.

Figure 3.11-3. Noise and Vibration Study Area



As part of the noise abatement analyses, sound level measurements are recorded to validate the project's model within FHWA Traffic Noise Model (Version 2.5). These sound level measurements are not used to establish the existing noise levels in the noise and vibration study area. Once the model is validated with the sound measurement data, the existing sound levels are established by modeling the worst noise hour traffic volumes.

Noise monitoring was performed from April to September 2022 at 58 locations within the noise and vibration study area. Two of the 58 monitoring sites were near the Ruby Junction Light-Rail OMF in Gresham, Oregon. Of

the 58 monitoring sites, 12 were long term (24 to 48 hours) and the other 46 were short term (15 minutes) monitoring sites. The long-term sites are required for analysis of transit operation noise and, therefore, were primarily located along the proposed LRT alignment and near transit facilities, and at residential and land use activities where sleep occurs. Section 2.4 of the Noise and Vibration Technical Report (as listed in Appendix H) provides additional details on measurement locations and levels.

Existing traffic noise levels were modeled to test the agreement of calculated and measured noise levels. Short-term measurements were used for model validation. The modeled and measured noise results are consistent with each state's noise policy as all Washington sites were validated within +/- 2 dBA and all Oregon sites were validated within +/- 3 dBA. Following model validation, sites were added to the model to predict noise levels at outdoor locations of frequent human use.

Worst-hour or loudest hour traffic from 2019 was used to model existing conditions and future-year 2045 traffic was used to model future conditions with the proposed Modified LPA and No-Build Alternative. Appendix K of the Noise and Vibration Technical Report (as listed in Appendix H) presents a comparison of noise levels by area for each traffic condition modeled.

Highway Traffic Noise Criteria

Federal, state, and local governments regulate and provide guidance for acceptable noise and vibration levels to ensure the public's health and wellbeing. For highways and transit systems, FHWA, FTA, ODOT, and WSDOT have developed guidance for assessing noise and vibration impacts. This assessment also considers applicable regulations from the City of Portland and City of Vancouver.

Table 3.11-1 summarizes FHWA's traffic noise abatement criteria. ODOT is responsible for implementing the FHWA regulations in Oregon, and WSDOT administers the FHWA regulations in Washington. Under ODOT policy, a traffic noise impact occurs if predicted noise levels approach within 2 dBA or exceed the FHWA criteria; the criteria apply to the peak noise impact hour. Under WSDOT policy, a traffic noise impact occurs if predicted noise levels approach within 1 dBA of or exceed the FHWA criteria. Both agencies consider an increase of 10 dBA or more to be a substantial impact.

Table 3.11-1. FHWA Traffic Noise Abatement Criteria by Land Use Category

Activity Category	Hourly $L_{eq}(h)$ (dBA)	Description of Activity
A	57 (exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 (exterior)	Residential (single and multifamily units).
C	67 (exterior)	Active sports areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	52 (interior)	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.
E	72 (exterior)	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A–D or F. Includes undeveloped land permitted for these activities.

Activity Category	Hourly $L_{eq}(h)$ (dBA)	Description of Activity
F	N/A	Agriculture, airports, bus yards, emergency services, industrial logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing
G	N/A	Undeveloped lands that are not permitted

Source: FHWA 2020
Note: The noise abatement criteria for Categories B, C, and E also apply to undeveloped land with building permits.
FHWA = Federal Highway Administration; Leq(h) = A-weighted (dBA) hourly equivalent steady state sound levels used for impact determination and are not design standards for abatement; N/A = not applicable

Construction Noise Criteria

In Washington, daytime construction noise is exempt from regulations in the Washington Administrative Code (WAC). Table 3.11-2 presents the WAC maximum allowable nighttime noise levels, above which the governing jurisdiction would require obtaining a noise variance. Washington State environmental noise standards (together with local noise regulations) apply to construction, and industrial, commercial, and residential noise sources including park and rides and transit stations.

Table 3.11-2. Washington State Environmental Noise Standard

Source of Noise	Receiver of Noise:[a] Residential	Receiver of Noise:[a] Commercial	Receiver of Noise:[a] Industrial
Residential	45	57	60
Commercial	47	60	65
Industrial	50	65	70

a Maximum allowable nighttime sound level in dBA. Sound level limits are based on measurements taken at the property lines of receiving properties.
dBA = A-weighted decibels

In addition to the noise standards listed in Table 3.11-2, there are exemptions for short-term noise exceedances, including those outlined in Table 3.11-3, based on the minutes per hour that the noise limit is exceeded.

Table 3.11-3. Washington State Exemptions for Short-Term Noise Exceedances

Statistical Descriptor [a]	Minutes Exceeded Per Hour	Adjustment to Maximum Sound Level
L_{25}	15 (25% of 1 hour)	+5 dBA
$L_{8.3}$	5 (8.3% of 1 hour)	+10 dBA
$L_{2.5}$	1.5 (2.5% of 1 hour)	+15 dBA

a L_{25}, $L_{8.3}$, and $L_{2.5}$ are the noise levels that are exceeded 25%, 8.3%, and 2.5% of the time (1 hour, in this case).
dBA = A-weighted decibels

In Oregon, OAR 340-35 sets allowable noise levels for individual vehicles and for industrial and commercial uses; however, sounds that originate on construction sites are exempt from the maximum allowable noise levels provided in OAR 340-35. Section 00292.32 of the ODOT Standard Specifications (Section 00292.32) includes construction noise abatement measures that apply to highway construction activities within Oregon. These abatement measures are considered mitigation and are discussed in Section 3.11.6.

Federal Transit Administration Noise Criteria

The FTA Transit Noise and Vibration Impact Assessment Manual provides FTA transit noise impact criteria applicable to noise generated by light-rail transit (FTA 2018). The FTA noise impact criteria identify the following noise-sensitive land use categories:

- **Category 1:** Buildings or parks where quiet is an essential element of their purpose.
- **Category 2:** Residences and buildings where people normally sleep. This includes residences, hospitals, and hotels where nighttime sensitivity is assumed to be of utmost importance.
- **Category 3:** Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, churches, office buildings, and other commercial and industrial land uses.

The L_{dn} is used to characterize noise exposure for residential areas (Category 2). For other noise-sensitive land uses, such as school buildings (Categories 1 and 3), noise is characterized by the maximum 1-hour L_{eq} during the period the facility is in use. FTA's criteria include two impact levels, shown in Figure 3.11-4 and summarized below:

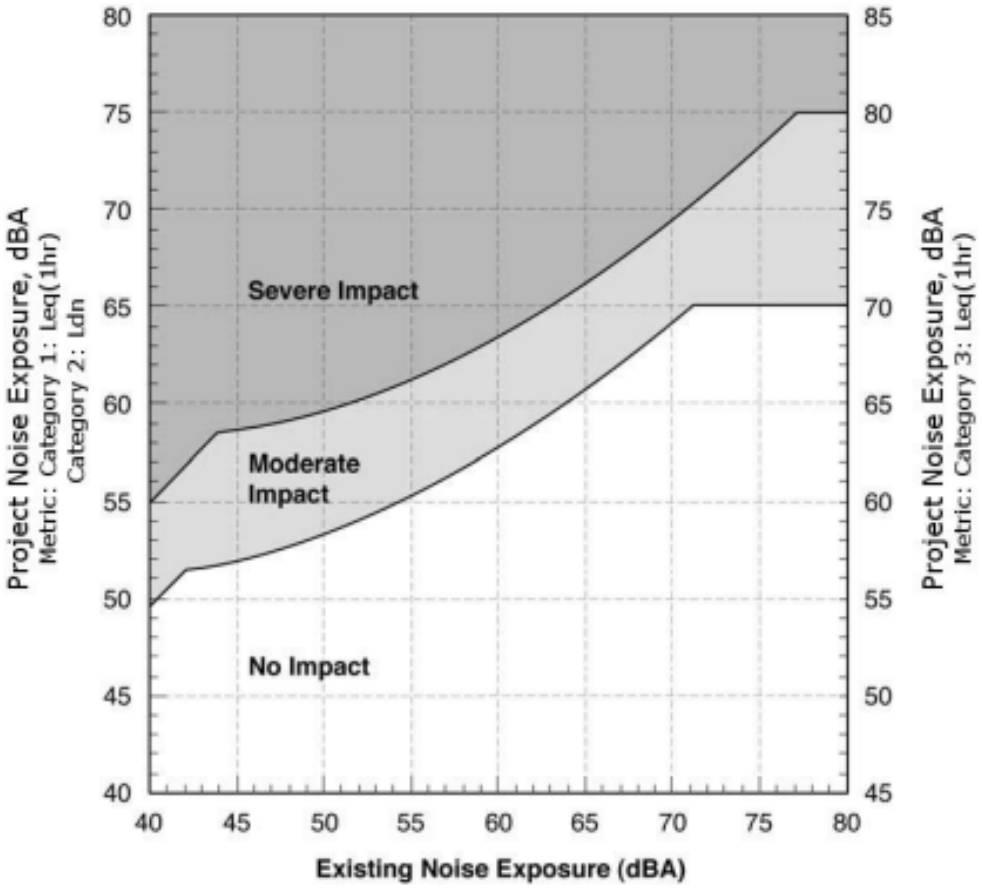
- **Severe Impact:** Project-generated noise in this range is likely to cause a high level of community annoyance. With severe impacts, alternative project alignments should be considered in an effort to avoid severe impacts.
- **Moderate Impact:** In this range, other project-specific factors must be considered to determine the magnitude of the impact and the need for mitigation. These other factors can include the predicted increase over existing noise levels, the types and number of noise-sensitive land uses affected, existing outdoor-indoor sound insulation, and the cost-effectiveness of mitigating noise to more acceptable levels.

No impact occurs when noise levels remain below the noise thresholds, which are dependent on land uses and existing noise levels.

Stationary Source Noise Criteria

Typically, state regulations are more stringent than FTA criteria, and in such cases, state regulations are used to estimate impacts from stationary noise sources. For example, the Oregon Department of Environmental Quality regulations (OAR 340-035-0035, Noise Control Regulations for Industry and Commerce) were used to estimate impacts from the proposed expansion of the Ruby Junction Light Rail Operations and Maintenance Facility (OMF) and Hayden Island light-rail station (shown in Table 3.11-4). However, FTA criteria still apply and are used to determine noise impacts from stationary sources where there are no state or local noise regulations or where FTA criteria are more stringent.

Figure 3.11-4. Federal Transit Administration Noise Impact Criteria for Transit Projects



Source: FTA, Noise and Vibration Impact Assessment Manual Figure 4-2, 2018

Table 3.11-4. Oregon Department of Environmental Quality Industrial and Commercial Noise Source Standards

Statistical Descriptor	Existing Noise Source (dBA) 7 a.m. to 10 p.m.	Existing Noise Source (dBA) 10 p.m. to 7 a.m.	New Noise Source (dBA) 7 a.m. to 10 p.m.	New Noise Source (dBA) 10 p.m. to 7 a.m.	New Source in Quiet Area (dBA) 7 a.m. to 10 p.m.	New Source in Quiet Area (dBA) 10 p.m. to 7 a.m.
L_1	75	60	75	60	60	55
L_{10}	60	55	60	55	55	50
L_{50}	55	50	55	50	50	45

Source: Oregon Administrative Rules 340-35-035, Tables 7, 8, and 9
a L_1, L_{10}, and L_{50} are the noise levels that are exceeded 1%, 10%, and 50% of the time (1 hour, in this case).
dBA = A-weighted decibels

City Noise Standards

In Portland, daytime construction noise up to 85 dBA is exempt, with additional exemptions for impact tools. From 7:00 p.m. to 7:00 a.m., and all day on Sundays, the City of Portland has restrictive noise regulations that apply to construction (City of Portland Municipal Code, Title 18, Noise Control). Under the noise control ordinance, virtually all major construction projects require a noise variance if work is planned during

nighttime hours or on Sundays. Large projects typically require coordination with the City of Portland's Noise Review Board, which often imposes additional restrictions on construction.

The City of Vancouver has incorporated WAC noise regulations (Table 3.11-2 and Table 3.11-3) into the Vancouver Municipal Code (VMC). The City of Gresham has incorporated Oregon Department of Environmental Quality noise regulations (Table 3.11-4) into the Gresham Noise Control Code (Gresham Revised Code Article 7.20).

Understanding Vibration

How Vibration Levels Are Measured

Ground-borne vibration is a form of energy that travels from a source through the ground to another location. Two types of vibration were analyzed—vibration from the operation of the proposed light-rail extension and vibration from construction.

The severity of impact caused by vibration is related to its velocity and is discussed in terms of both inches per second and decibels, as appropriate. Velocity of vibration in decibels is noted as "VdB."

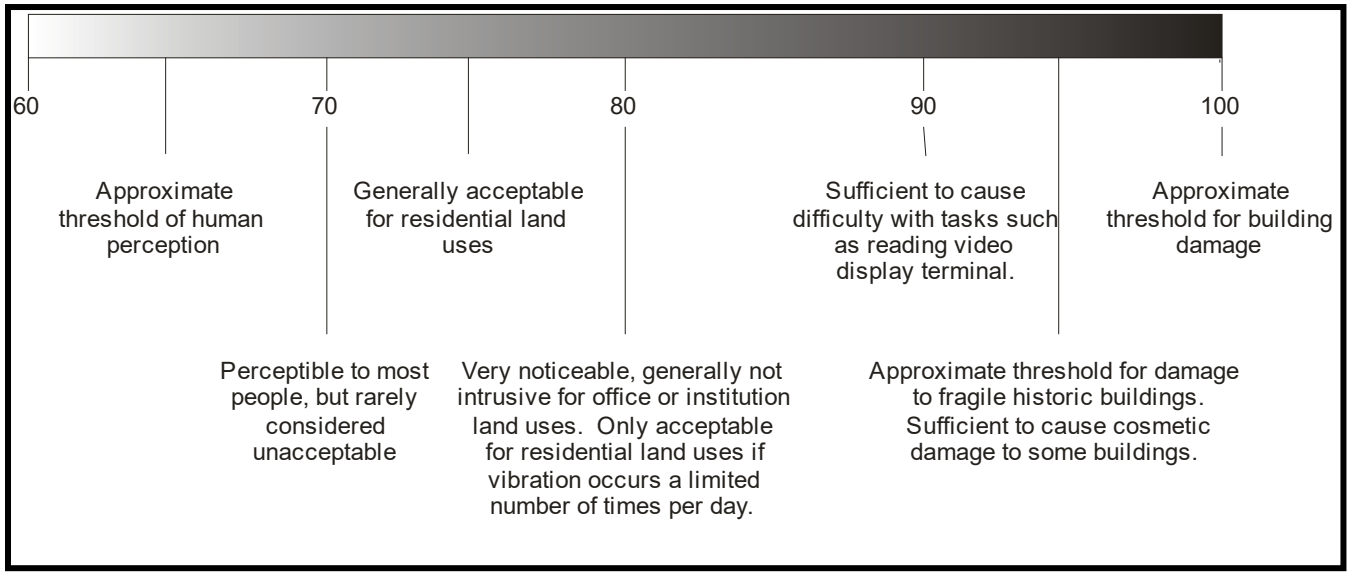
Ground-Borne Vibration vs. Ground-Borne Noise

The effects of ground-borne vibration include perceived movement of building floors, rattling of windows, or shaking of items on shelves. When ground-borne vibration creates a rumbling noise inside buildings, it is called ground-borne noise.

Typical Vibration Levels

Figure 3.11-5 gives a general idea of the effects of different levels of vibration on humans and buildings. Existing levels of building vibration from traffic and other local sources are usually in the range of 40 to 50 VdB, which is well below the range of human perception.

Figure 3.11-5. Human and Building Response to Ground-Borne Vibration Levels



Source: FTA 1995

Vibration Criteria and Analysis Methods

Vibration Criteria

FTA has developed procedures and methods for predicting and assessing noise and vibrations impacts, including specific metrics and impact criteria that are used in noise and vibration assessments that apply to light-rail transit. FHWA does not have criteria or requirements for analysis of vibration impacts.

Table 3.11-5 summarizes FTA's impact criteria for most buildings. Some buildings, such as concert halls, TV and recording studios, and theaters, can be very sensitive to ground-borne vibration and ground-borne noise but do not fit into the three categories shown in Table 3.11-5. Because of the sensitivity of these buildings, the FTA has developed ground-borne vibration and ground-borne noise criteria for "special buildings," shown in Table 3.11-6.

Table 3.11-5. FTA Ground-Borne Vibration and Noise Impact Criteria

Land Use Category	Ground-Borne Vibration Impact Levels Frequent [a] Events	Ground-Borne Vibration Impact Levels Occasional [b] Events	Ground-Borne Vibration Impact Levels Infrequent [c] Events	Ground-Borne Noise Impact Levels Frequent [a] Events	Ground-Borne Noise Impact Levels Occasional [b] Events	Ground-Borne Noise Impact Levels Infrequent [c] Events
Category 1: Buildings where low ambient vibration is essential for interior operations	65 VdB [d]	65 VdB [d]	65 VdB [d]	N/A [e]	N/A [e]	N/A [e]
Category 2: Residences and buildings where people normally sleep	72 VdB	75 VdB	80 VdB	35 dBA	38 dBA	43 dBA
Category 3: Institutional land uses with primarily daytime use	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

Source: FTA 2018

a "Frequent Events" is defined as more than 70 vibration events per day. Most rapid transit projects fall into this category.

b "Occasional Events" are defined as 30 to 70 vibration events per day. Most commuter trunk lines fall into this category.

c "Infrequent Events" is defined as fewer than 30 vibration events per day. This category includes most commuter-rail systems.

d This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research equipment would require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the heating, ventilation, and air-conditioning system and stiffened floors.

e Vibration-sensitive equipment is generally not sensitive to ground-borne noise.

dBA = A-weighted decibels; FTA = Federal Transit Administration; N/A = not applicable; VdB = vibration in decibels

Table 3.11-6. Ground-Borne Vibration and Noise Impact Levels for Special Buildings

Type of Building or Room	Ground-Borne Vibration Impact Levels Frequent [a] Events	Ground-Borne Vibration Impact Levels: Occasional or Infrequent [b] Events	Ground-Borne Noise Impact Levels: Frequent [a] Events	Ground-Borne Vibration Impact Levels: Occasional or Infrequent [b] Events
Concert Halls	65 VdB	65 VdB	25 dBA	25 dBA
TV Studios	65 VdB	65 VdB	25 dBA	25 dBA
Recording Studios	65 VdB	65 VdB	25 dBA	25 dBA
Auditoriums	72 VdB	80 VdB	30 dBA	38 dBA
Theaters	72 VdB	80 VdB	35 dBA	43 dBA

Source: FTA 2018
Note: If the building will rarely be occupied when the trains are operating, there is no need to consider impacts. As an example, consider locating a commuter-rail line next to a concert hall. If no commuter trains will operate after 7 p.m., the trains would rarely interfere with the use of the hall.
a "Frequent Events" is defined as more than 70 vibration events per day. Most rapid transit projects fall into this category.
b "Occasional Events" are defined as 30 to 70 vibration events per day. Most commuter trunk lines fall into this category. "Infrequent Events" is defined as fewer than 30 vibration events per day. This category includes most commuter-rail systems.
dBA = A-weighted decibels; VdB = vibration in decibels

City Vibration Standards

The City of Portland (Chapter 33.262, Off-Site Impacts) restricts continuous, frequent, or repetitive vibrations that exceed a 0.002 gravitational constant peak or the maximum acceleration during a specific event. Vibrations from temporary construction and vehicles that leave the site (such as trucks and trains) are exempt. Temporary construction vibration is not defined; however, vibrations lasting less than 5 minutes per day are also exempt. Vibrations from primarily on-site vehicles and equipment are not exempt.

The City of Gresham does not regulate vibration.

The City of Vancouver has incorporated vibration regulations into the VMC, including prohibiting off-site vibration impacts that are discernible without instruments at the property line. This prohibition would apply to all nighttime construction activities and the operation of light-rail stations and park and rides. Construction activity between the hours of 7 a.m. and 8 p.m. is exempt from these vibration regulations. The operations of public streets and sidewalks, rail maintenance yards, and essential public facilities, such as the interstate highway system, are exempt from these regulations 24 hours a day.

Existing Noise Levels in the Noise and Vibration Study Area

Traffic noise levels were modeled at 875 locations representing approximately 1,204 noise-sensitive land uses within the noise and vibration study area. For the light-rail transit analysis, noise levels were modeled at 16 locations representing 52 noise-sensitive land uses. Some of the modeling locations used for the traffic noise analysis were also used for the transit analysis. Each of these locations has one or more noise receptors that constitute sensitive land uses, such as a residence, historic buildings, hotel, motel, or park (see sidebar). Existing outdoor noise levels range from 49 to 75 dBA L_{eq}, with 24-hour L_{dn} noise levels ranging from 53 to 75 dBA.

Overall, noise levels in the noise and vibration study area are dominated by traffic on I-5. The year 2019 was used for existing conditions because it aligns with the traffic study completed for the IBR Program. Under existing conditions (2019), an estimated 160 noise-sensitive land uses approach or exceed the applicable traffic noise criteria in the noise and vibration study area. This includes single-family and multifamily residences, along with several hotels, parks, schools, and a cemetery. Of the existing noise-sensitive land uses that exceed applicable noise criteria levels, 50 are in Portland and 111 are in Vancouver. Chapter 3 of the Noise and Vibration Technical Report (as listed in Appendix H) provides the existing modeled locations and noise levels for each subarea summarized below.

What are noise-sensitive receptors and residential equivalents?

A noise-sensitive receptor is a property where frequent human use occurs and where a lower noise level would be beneficial. The nuisance level for traffic noise is perceived differently by people depending on the situation. For instance, roadway noise may not bother people walking to a commercial establishment but may disturb people at a backyard pool or while they are sleeping. Residential equivalency is a measurement of the amount of use at special sites such as schools, parks, churches, and hospitals.

Portland Existing Modeled Traffic Noise Levels

Current noise levels meet or exceed the ODOT Noise Abatement Approach Criteria (NAAC) at 50 locations adjacent to I-5, including approximately 19 floating homes, with noise levels of 65 to 69 dBA L_{eq}. Existing noise levels at multilevel apartment units located along N Marine Drive also approach or exceed the ODOT NAAC. These apartment units have private outdoor patios facing N Marine Drive, with noise levels ranging from 65 to 71 dBA L_{eq}.

Downtown Vancouver Existing Modeled Traffic Noise Levels

The analysis of noise levels in downtown Vancouver focuses on I-5, SR 14, and associated ramps. Noise levels in downtown Vancouver currently range from 66 to 72 dBA $L_{eq.}$ The traffic noise model also includes local streets that influence noise in the noise and vibration study area. Currently, 38 noise-sensitive sites approach or exceed the WSDOT noise abatement criteria (NAC), primarily due to I-5 traffic noise. Locations that would undergo noise impacts are mostly clustered at apartment buildings located just southwest of the I-5/E Mill Plain Boulevard interchange, C Street and E 7th Street, and a newly constructed building along Washington Street between West 4th and West 5th Streets.

Fort Vancouver Existing Modeled Traffic Noise Levels

At the Vancouver National Historic Reserve (VNHR), including the Fort Vancouver National Historic Site and nearby areas, noise levels currently range from 52 to 75 dBA L_{eq}, with the highest levels at unshielded areas along I-5 and SR 14. Currently, six modeled locations along the Fort Vancouver Park Trail and Confluence Land Bridge Trail within the Fort Vancouver Historic District, and three modeled locations along the Waterfront Renaissance Trail approach or exceed the WSDOT NAC.

Vancouver East Existing Modeled Traffic Noise Levels

East of I-5 and north of E Mill Plain Boulevard, noise levels currently range from 49 to 73 dBA L_{eq}, with the highest levels at residences not located behind existing noise walls north of E Fourth Plain Boulevard. Currently, 16 locations that represent 17 residential equivalents (16 residences and one modeled location n at Marshall Park) approach or exceed the WSDOT NAC.

Vancouver West Existing Modeled Traffic Noise Levels

West of I-5 and north of E Mill Plain Boulevard, current noise levels range from 49 to 75 dBA L_{eq}, with the highest levels at residences located close to I-5 both north and south of E 39th Street. Currently, 42 residences, two offices, the Kiggins Bowl, and an outdoor area on the east side of Discovery School meet or exceed the WSDOT NAC.

Existing Noise Levels for Light-Rail Transit Analysis

Existing noise level data for the light-rail analysis were taken from on-site measurements and following methods in the FTA Transit Noise and Vibration Manual. Locations in the transit corridor that were used for the traffic noise analysis were also used for the light-rail analysis. The noise levels provided represent primarily residential uses, with some uses such as hotels that include overnight sleeping. Existing noise levels ranged from 69 to 77 L_{eq} and 77 to 83 L_{dn} in downtown Vancouver; from 58 to 73 L_{eq} and 66 to 81 L_{dn} at sites in north Portland; and from 69 to 71 L_{eq} and 67 to 70 L_{dn} in the area around the Ruby Junction Light-Rail OMF.

3.11.3 Long-Term Benefits and Reasonably Foreseeable Effects

Long-term benefits and reasonably foreseeable effects on noise and vibration were assessed for the noise and vibration study area, defined in Section 3.11.2, and the temporal scope described in the Chapter 3 introduction. Table 3.11-7 summarizes the noise and vibration effects of the Modified LPA, including design options, and No-Build Alternative followed by a discussion of the reasonably foreseeable effects.

Table 3.11-7. Long-term Noise and Vibration Benefits and Effects

0 Effect	1 No-Build	2: IBR Program Recommended Design Options Modified LPA with the Single-Level Fixed-Span Bridge Configuration, One Auxiliary Lane, with C Street Ramps, Centered I-5, and All Five Park and Rides	3 Modified LPA with Double-Deck Fixed-Span Bridge Configuration, One Auxiliary Lane, with C Street Ramps, Centered I-5, and All Five Park and Rides	4 Modified LPA with Single-Level Movable-Span Bridge Configuration, One Auxiliary Lane, with C Street Ramps, Centered I-5, and All Five Park and Rides	5 Modified LPA with Double-Deck Fixed-Span Bridge Configuration, Two Auxiliary Lanes, without C Street Ramps, I-5 Westward Shift, and All Five Park and Rides
Traffic noise	• 216 receptors would exceed highway noise thresholds. • No receptors would have moderate or severe transit noise impact levels.	• Without mitigation, 195 receptors would exceed highway noise thresholds due to the acquisition of floating homes located near the Columbia River light rail transit bridge alignment of the Modified LPA. • With mitigation, eight existing noise walls in Vancouver would be replaced as necessary for project construction along with two new noise walls in Vancouver and one new noise wall in Portland, which collectively would reduce the number of traffic noise impacts to 113.	• The double-deck fixed-span bridge configuration design option would have similar effects to the single-level fixed-span bridge configuration design option, as listed in Column 2, except: – Users on the shared-use path across the Columbia River bridges would have more shielding and less exposure to noise from highway vehicles. • Mitigation would be consistent with the single-level fixed-span bridge configuration design option, as listed in Column 2.	• The single-level movable-span bridge configuration design option would have similar effects as listed in Column 2 for the single-level fixed-span bridge configuration design option.	• The double-deck fixed-span bridge configuration, two auxiliary lanes, without C Street Ramps, and I-5 westward shift design options would each have similar effects as listed in Column 3 for the single-level fixed-span bridge configuration, one auxiliary lane, with C Street ramps, and centered I-5 design options, except: – The I-5 westward shift design option would result in twelve less receptors exceeding highway noise thresholds due to the acquisition of a 12-unit apartment complex located at E 7th Street and E C Street.

0 Effect	1 No-Build	2: IBR Program Recommended Design Options Modified LPA with the Single-Level Fixed-Span Bridge Configuration, One Auxiliary Lane, with C Street Ramps, Centered I-5, and All Five Park and Rides	3 Modified LPA with Double-Deck Fixed-Span Bridge Configuration, One Auxiliary Lane, with C Street Ramps, Centered I-5, and All Five Park and Rides	4 Modified LPA with Single-Level Movable-Span Bridge Configuration, One Auxiliary Lane, with C Street Ramps, Centered I-5, and All Five Park and Rides	5 Modified LPA with Double-Deck Fixed-Span Bridge Configuration, Two Auxiliary Lanes, without C Street Ramps, I-5 Westward Shift, and All Five Park and Rides
					• Mitigation would be consistent with the single-level fixed-span bridge configuration design option with each design option, as listed in Column 3, except the I-5 westward shift design option would include one less new noise wall in downtown Vancouver as a result of Program acquisitions at E 7th Street and E C Street.

0 Effect	1 No-Build	2: IBR Program Recommended Design Options Modified LPA with the Single-Level Fixed-Span Bridge Configuration, One Auxiliary Lane, with C Street Ramps, Centered I-5, and All Five Park and Rides	3 Modified LPA with Double-Deck Fixed-Span Bridge Configuration, One Auxiliary Lane, with C Street Ramps, Centered I-5, and All Five Park and Rides	4 Modified LPA with Single-Level Movable-Span Bridge Configuration, One Auxiliary Lane, with C Street Ramps, Centered I-5, and All Five Park and Rides	5 Modified LPA with Double-Deck Fixed-Span Bridge Configuration, Two Auxiliary Lanes, without C Street Ramps, I-5 Westward Shift, and All Five Park and Rides
Transit noise and vibration	No vibration impacts without the extension of light-rail.	• Transit noise impacts would occur at 12 receptors in downtown Vancouver at a 12-unit apartment complex located at E 7th Street and E C Street. • Transit vibration impacts would occur at 13 receptors in downtown Vancouver, including the same 12-unit apartment complex located at E 7th Street and E C Street and a movie theater located at E 8th Street and E C Street.	• The double-deck fixed-span bridge configuration design option would have similar effects as the single-level fixed-span bridge configuration design option, as listed in Column 2.	• The single-level movable-span bridge configuration design option would have similar effects as the single-level fixed-span bridge configuration design option, as listed in Column 2.	• The double-deck fixed-span bridge configuration, two auxiliary lanes, without C Street Ramps, and I-5 westward shift design options would each have similar effects as listed in Column 3 for the single-level fixed-span bridge configuration, one auxiliary lane, with C Street ramps, and centered I-5 design options, except: – The I-5 westward shift design option would not result in transit noise or transit vibration impacts as a result of Program acquisitions at impact locations at E 7th Street and E C Street.

Note: The underlined design options shown in columns 3 through 5 identify the specific effects on noise and vibration for that particular design option compared to the Modified LPA with Recommended Design Options (column 2). For example, the effects of the double-deck fixed-span (column 3) would occur with any other combination of the auxiliary lanes, C Street ramps, I-5 alignment, and park and ride design options.
I-5 = Interstate 5; IBR = Interstate Bridge Replacement; LPA = Locally Preferred Alternative

No-Build Alternative

Under existing conditions (2019) noise levels meet or exceed applicable noise criteria at approximately 161 out of 1,204 noise-sensitive land uses in the noise and vibration study area; that number would rise to 215 under the No-Build Alternative (2045). Background traffic growth would cause an increase in traffic noise levels throughout the noise and vibration study area. Under the No-Build Alternative, routine maintenance of the existing noise walls in Vancouver would occur, but no new noise walls would be constructed. Under the No-Build Alternative, none of transit improvements associated with the IBR Program would occur, so there would be no new transit noise or vibration impacts from the Program.

This analysis does not address vibration levels associated with the No-Build Alternative because no new source of vibration is anticipated under the No-Build Alternative.

Portland Modeled Traffic Noise Levels

Forty-nine of the 50 receptors where existing noise levels approach or exceed the ODOT NAAC are predicted to continue to approach or exceed the ODOT traffic noise criteria under the No-Build Alternative (2045). In addition to these 49 receptors, it is predicted that traffic noise levels at 15 more locations near I-5 and N Marine Drive will approach or exceed the ODOT traffic noise criteria under the No-Build Alternative. Noise levels under the No-Build Alternative would range from 45 to 70 dBA L_{eq} with a 1 to 2 dBA increase over existing conditions at most locations due to an increase in traffic volumes.

Under the No-Build Alternative, noise levels at the estimated 19 floating homes that currently experience noise impacts, and an additional 10 floating homes, are predicted to approach or exceed the ODOT NAAC with noise levels of 65 to 69 dBA $L_{eq.}$ At most locations, noise levels would increase by 1 to 2 dBA due to an increase in traffic volumes in 2045. Most of the remaining traffic noise levels above the ODOT NAAC are located at the apartment complexes along N Marine Drive. Under the No-Build Alternative noise levels are predicted to exceed the ODOT NAAC at the same 30 apartments under the existing conditions and an additional four apartments within the Newport Apartment complex (Table 4-1 of the Noise and Vibration Technical Report, as listed in Appendix H), with levels ranging from 49 to 70 dBA L_{eq}. Most locations are predicted to experience an increase of 1 to 2 dBA over existing noise levels. Traffic noise levels under the No-Build Alternative also approach or exceed the ODOT NAAC at one commercial property.

Downtown Vancouver Modeled Traffic Noise Levels

Under the No-Build Alternative, traffic noise levels in downtown Vancouver are predicted to approach or exceed the WSDOT traffic noise criteria at the same 26 multifamily residences, kindergarten school at Providence Academy and three trails as under the existing conditions, and at eight additional residential units and one additional trail use (see Table 4-3 of the Noise and Vibration Technical Report, as listed in Appendix H). No-Build Alternative noise levels would range from 51 to 73 dBA L_{eq}. Compared to existing conditions, noise levels would increase 1 to 7 dBA, with most modeled locations showing an increase of 1 to 2 dBA. Increases in noise levels would result from an increase in traffic volumes from existing conditions to the year 2045. The highest predicted noise level under the No-Build Alternative would be 73 dBA L_{eq} at the apartments at 400 Washington Street.

Fort Vancouver Modeled Traffic Noise Levels

Noise levels at the VNHR under the No-Build Alternative are projected to range from 53 to 76 dBA L_{eq}, with the highest levels at unshielded areas along I-5 and SR 14. In general, noise levels are predicted to increase by 1 to 2 dBA over existing conditions within the VNHR due to an increase in traffic volumes. Currently, noise levels within the Fort Vancouver Historic District along the Fort Vancouver Trail and Confluence Land Bridge Trail, and along the Waterfront Renaissance Trail located outside the Fort Vancouver Historic District, approach or exceed the WSDOT NAC. Under the No-Build Alternative, the same sites would continue to approach or exceed

the WSDOT NAC, with two additional trail use locations in the Fort Vancouver Historic District and one Historic District/office location exceeding the WSDOT NAC (see Table 4-5 of the Noise and Vibration Technical Report, as listed in Appendix H).

North Vancouver, East of I-5 Modeled Traffic Noise Levels

Future noise levels under the No-Build Alternative at the modeling locations in this area of north Vancouver east of I-5 and north of E Mill Plain Boulevard ranged from 50 to 74 dBA L_{eq}, an increase of 1 to 3 dBA over existing noise levels. These increases are due to an increase in traffic volumes from existing conditions to the year 2045. Currently, 17 locations approach or exceed the WSDOT NAC. Under the No-Build Alternative, 29 locations approach or exceed the WSDOT NAC (Table 4-7 of the Noise and Vibration Technical Report, as listed in Appendix H). Noise levels do not approach or exceed the WSDOT NAC at the hospital, church, or cemeteries located in this subarea, but they do exceed the criteria at 23 residences, one recreation area at Leverich Park, and at athletic fields and other outdoor-use areas at Marshall Park.

North Vancouver, West of I-5 Modeled Traffic Noise Levels

Future No-Build Alternative noise levels at the modeling locations in this subarea north of Mill Plain Boulevard to Discovery Middle school range from 50 to 76 dBA L_{eq}, an increase of 1 to 3 dBA over existing noise levels. These increases are due to an increase in traffic volumes from existing conditions to the year 2045. Under the No-Build Alternative, the number of residences with noise levels that would approach or exceed the WSDOT NAC is predicted to increase from the current 47 locations to 65. The same locations predicted to reach the WSDOT NAC under existing conditions would also exceed the WSDOT NAC under the No-Build Alternative, along with 18 additional residences and two additional use areas at the Kiggins Bowl, one outdoor use at Discovery Middle School, and two offices (see Table 4-9 of the Noise and Vibration Technical Report, as listed in Appendix H).

Modified LPA

The analysis of the Modified LPA includes all design options (including the Recommended Design Options) described in Chapter 2, Description of Alternatives. If there is a difference in the reasonably foreseeable effects among design options, those differences are identified and described specifically.

Without mitigation, traffic noise impacts under the proposed Modified LPA with the single-level fixed-span bridge configuration and one auxiliary lane (Recommended Design Options) are expected to increase (195 impacts) compared to existing conditions (160 impacts) due to an increase in future traffic volumes and shift in roadway alignments. Compared to the No-Build Alternative (216 impacts), the Modified LPA with Recommended Design Options would have fewer traffic noise impacts due to acquisitions near the new Columbia River bridge alignment. IBR Program acquisitions for the future Columbia River bridge alignment would include floating homes located between Hayden Island and the Oregon mainland.

The Modified LPA with the single-level fixed-span bridge configuration and one auxiliary lane design options would displace existing noise walls in Vancouver. Section 3.7.6 below evaluates new noise walls that would replace them. All existing noise walls that would be replaced in-kind (i.e., no changes to wall length or height providing at least the same noise reduction that the existing noise walls provide) are evaluated as part of this analysis (see Chapter 7 of the Noise and Vibration Technical Report, as listed in Appendix H for details). With the 11 noise walls evaluated as feasible and reasonable to include in the proposed IBR Program, the predicted traffic noise impacts would be mitigated to below the NAC at 82 residences, leaving 113 impacts with the Modified LPA.

Figure 3.11-6 through Figure 3.11-12 show the modeled noise impacts of the Modified LPA with all Design Options, at locations within the noise and vibration study area. Potential changes in noise and vibration impacts for the design options were evaluated qualitatively by reviewing design changes in relation to the

Modified LPA with Recommended Design Options. Results from the noise analysis conducted for individual historic properties are discussed in Section 3.8, Cultural Resources.

The design options are discussed qualitatively for comparative purposes.

Modeled Traffic Noise Levels

Portland/Hayden Island

Long-term reasonably foreseeable effects on noise levels would not differ among the Modified LPA design options in Portland or Hayden Island. The Modified LPA would meet or exceed the ODOT NAAC at 57 locations representing 56 residences and one athletic field at Delta Park. A substantial increase impact of 10 dBA over existing noise levels is predicted at five residences located at the Jantzen Beach RV park. Figure 3.11-6 and Figure 3.11-7 show the traffic noise impact locations in Portland.

Under the Modified LPA, noise levels at modeled locations in Portland would range from 49 to 71 dBA L_{eq}. Most locations would experience an increase of 2 to 4 dBA over existing conditions, with increases of up to 11 dBA at one location, site PD-007, which represents one mobile home in the Jantzen Beach recreational vehicle (RV) park on Hayden Island. Noise levels would be 2 dBA above to 2 dBA below noise levels under the No-Build Alternative, at most locations.

The greatest increase in noise levels under the Modified LPA is predicted at the Jantzen Beach RV park, located at the north end of Hayden Island and west of I-5. Noise levels in this area are predicted to increase 4 to 11 dBA over existing conditions and 4 to 10 dBA above No-Build Alternative noise levels; this is because the Modified LPA would shift the alignment of I-5 closer to homes at the RV park. While noise levels would increase at all of the RV homes, as shown in Figure 3.11-7 the modeling showed that five of the RV homes may experience a substantial noise increase (defined as an increase of 10 dBA or greater). An existing block wall at the RV park and a nearby hotel building provides some shielding against noise, as modeled. Noise levels under the Modified LPA would not approach or exceed ODOT's NAAC impact criteria at the RV park; however, the increase in noise levels would meet the threshold of 10 dBA over existing noise levels, making this a substantial increase.

Other areas that are predicted to undergo ODOT NAAC impacts include the floating homes in North Portland Harbor (sites PD-077 to PD-082, PD-084 to PD-090), the apartments located closest to N Marine Drive (PD-157A to PD-161A-C, PD-163C, PD-168A-C to PD-173A-C), and one soccer field (PD-192) at Delta Park. In the area between Hayden Island and the Oregon mainland, the IBR Program would acquire 38 floating homes (represented by Sites PD-091 to PD-124, PD-126, PD-127, and PD-129), one office (PD-125), and one home located along the Oregon shoreline (PD-128) to allow for the new Columbia River bridge alignment. Site PD-104 represents two floating homes, which is how 37 sites represent 38 floating homes. Due to this total of 40 acquisitions, the Modified LPA would result in fewer sites predicted to undergo an increase in noise than under the No-Build Alternative. The 40 total displacements in the area between Hayden Island and the Oregon mainland are represented by modeled sites PD-091 to PD-129. As shown in Figure 3.11-7, the floating homes at the end of the dock (represented by modeled sites PD-076 and PD-083) experience additional noise shielding from the existing terrain and would not be subject to an NAAC impact. In addition to the floating home displacements, modeled sites PD-038, PD-039, PD-040, PD-042, PD-043, PD-046, PD-048, PD-050 to PD-055, PD-128, PD-131, and PD-132, which represent several commercial businesses and restaurants on N Center Avenue, would be displaced.

Figure 3.11-6. Modified LPA with Recommended Design Options – 2045 Traffic Noise Impacts – Portland Mainland

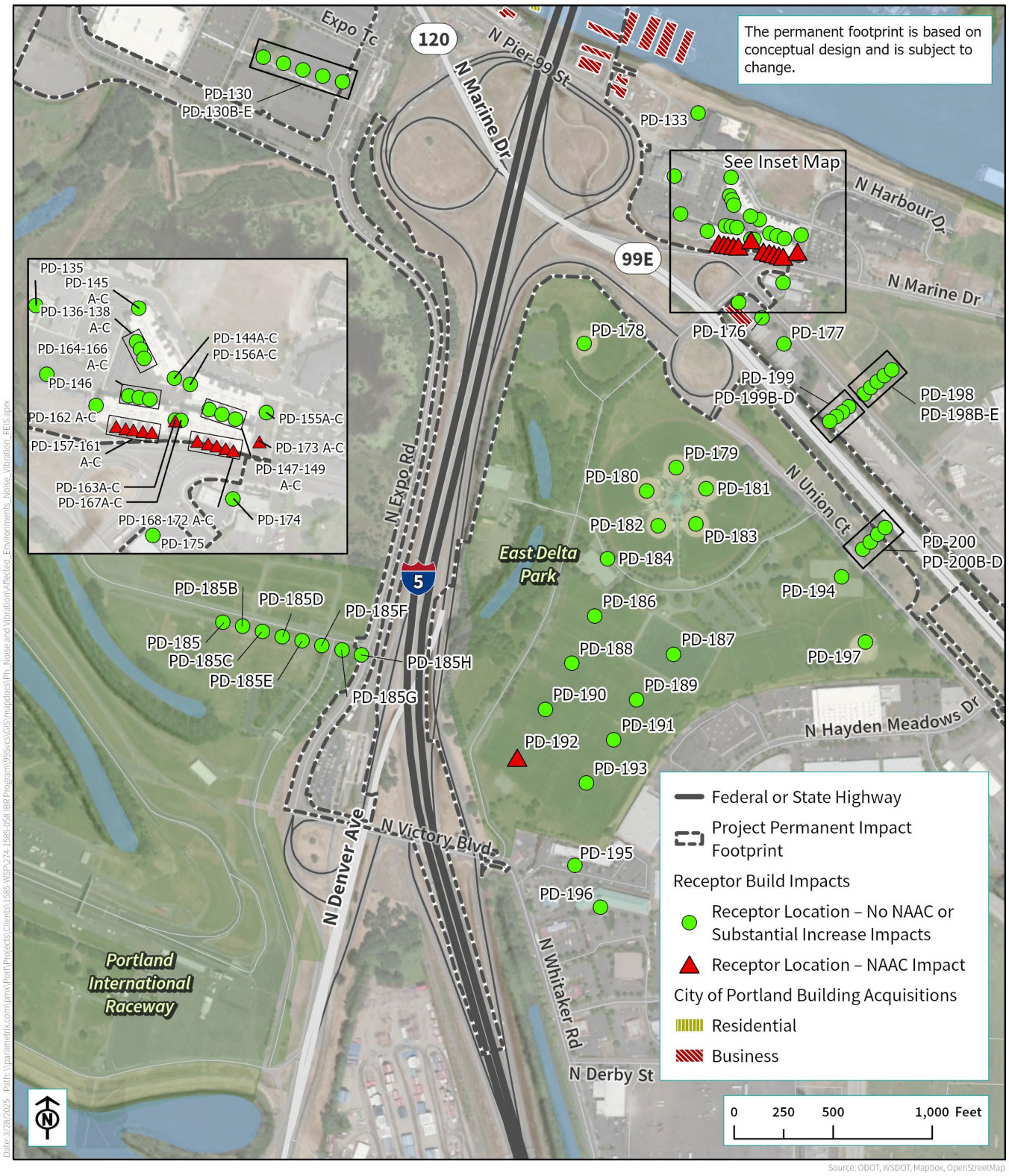


Figure 3.11-7. Modified LPA with Recommended Design Options – 2045 Traffic Noise Impacts – Portland/Hayden Island

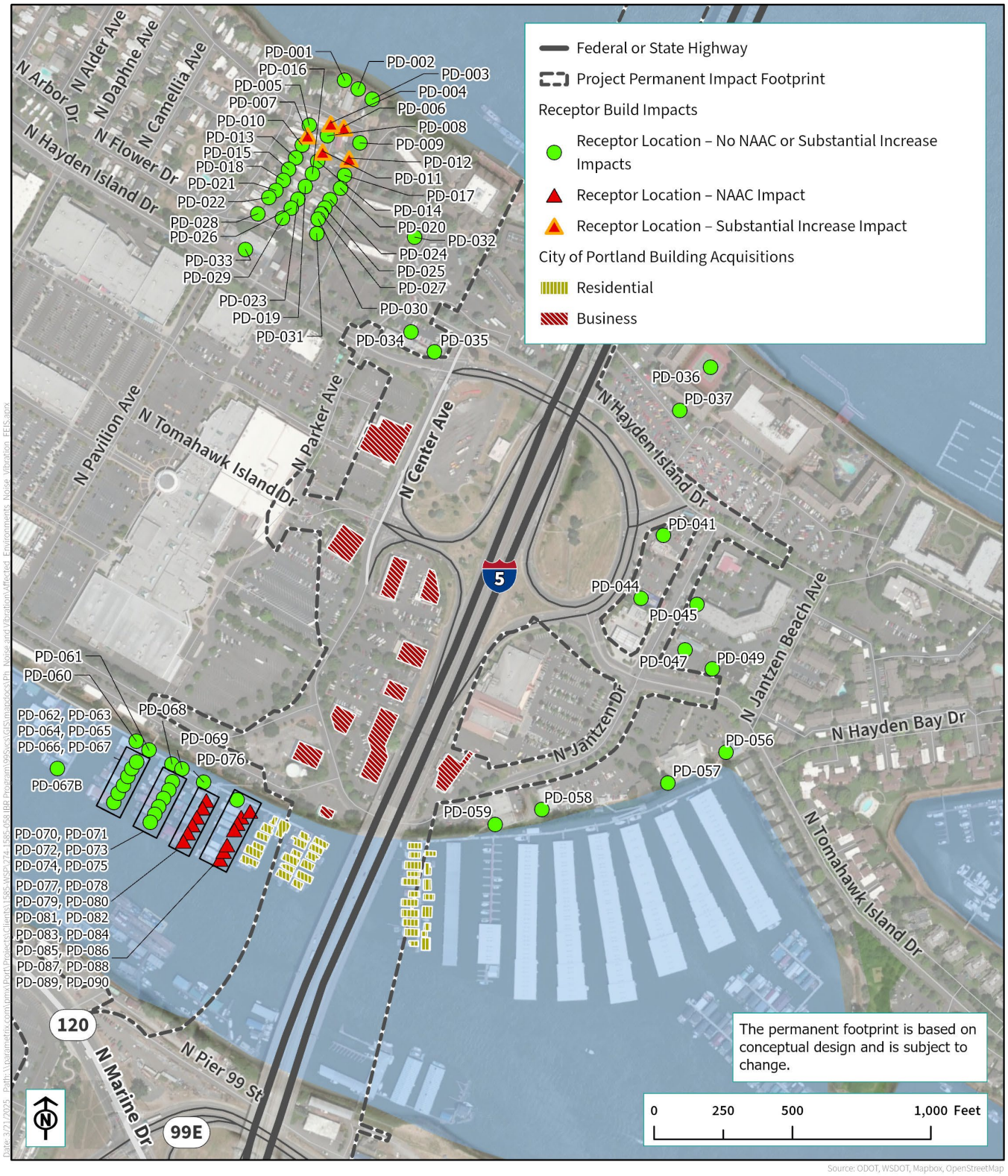


Figure 3.11-8. Modified LPA with Recommended Design Options – 2045 Traffic Noise Impacts – I-5/SR 14 Interchange

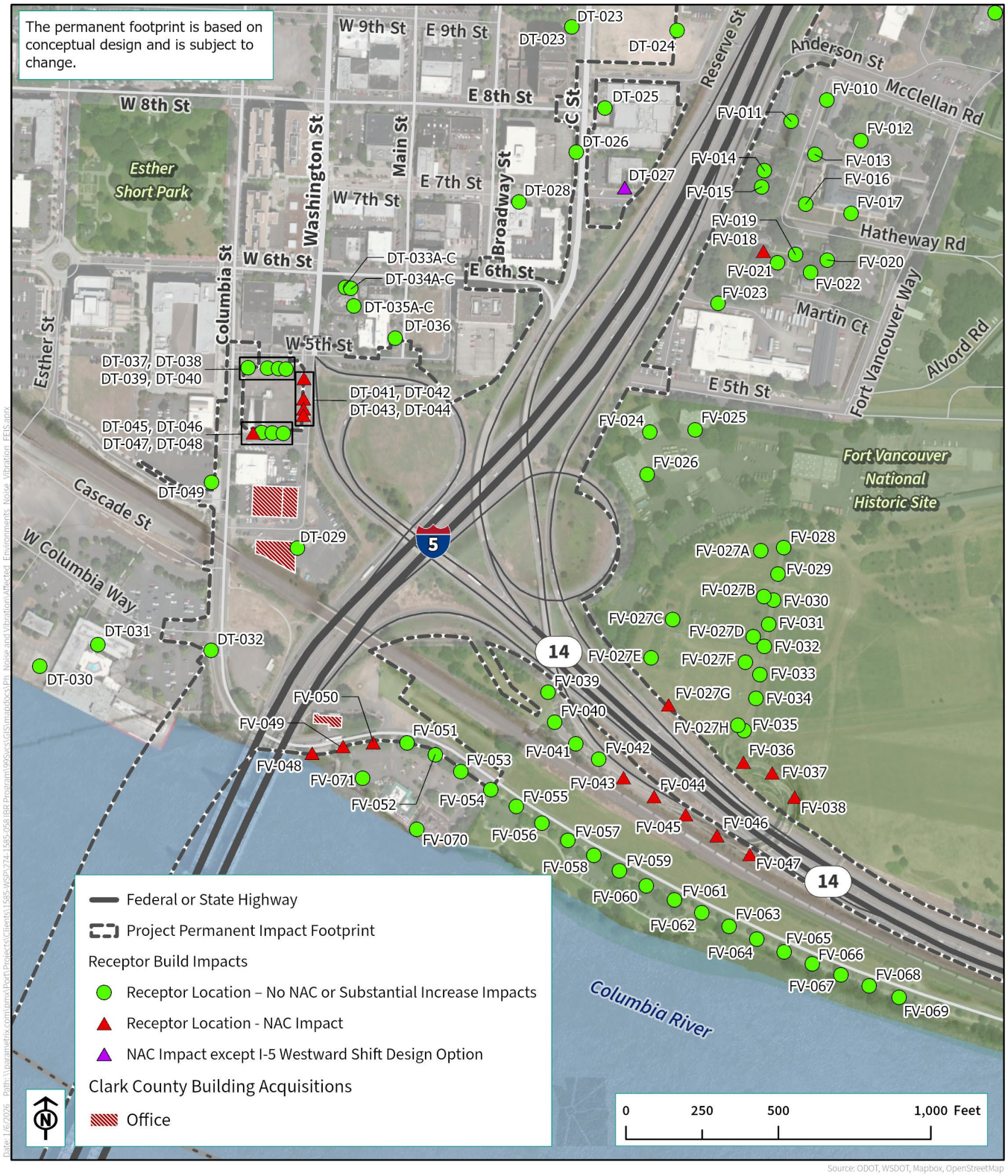


Figure 3.11-9. Modified LPA with Recommended Design Options – 2045 Traffic Noise Impacts – E 8th Street to McLoughlin Boulevard

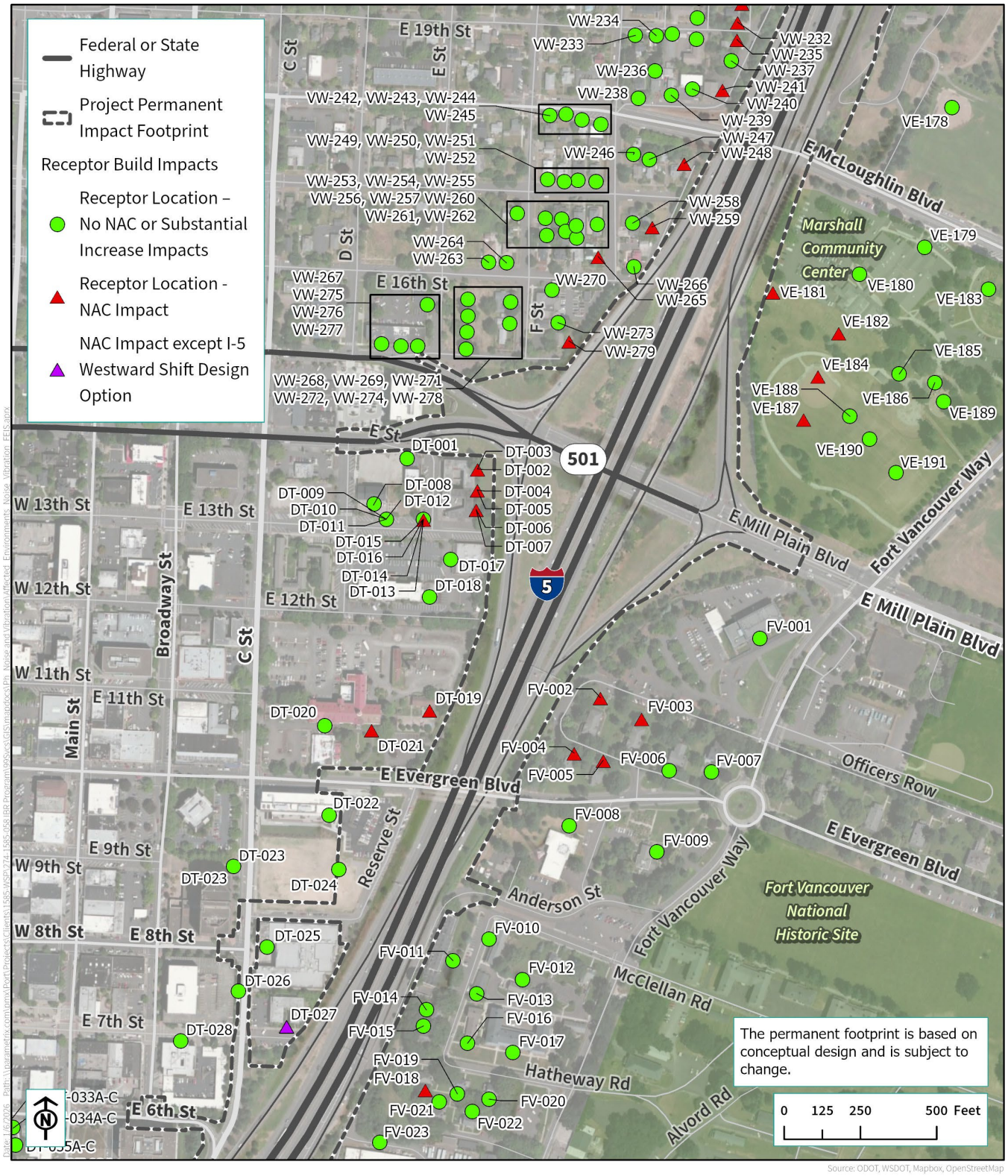


Figure 3.11-10. Modified LPA with Recommended Design Options – 2045 Traffic Noise Impacts – McLoughlin Boulevard to E 30th Street

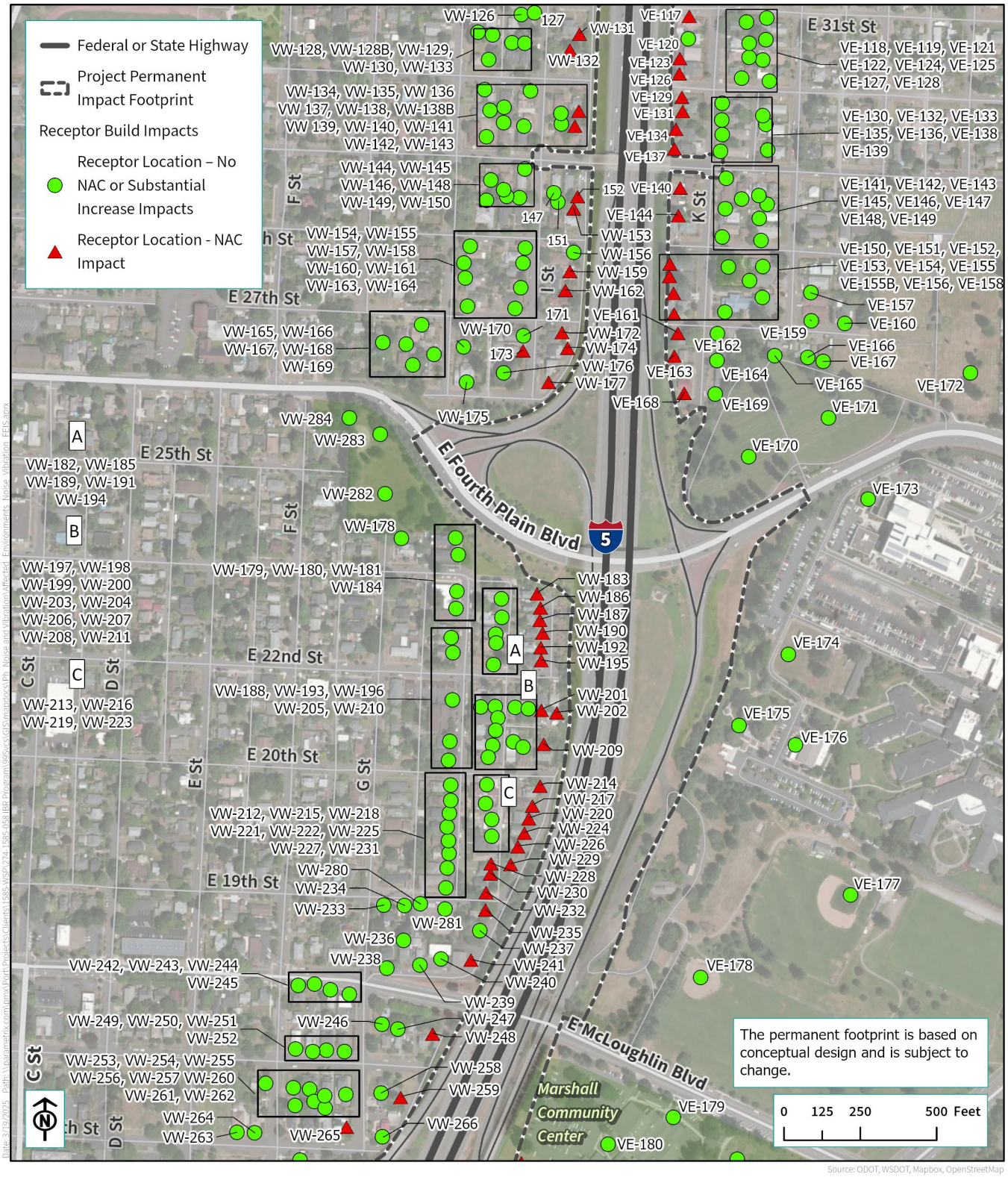
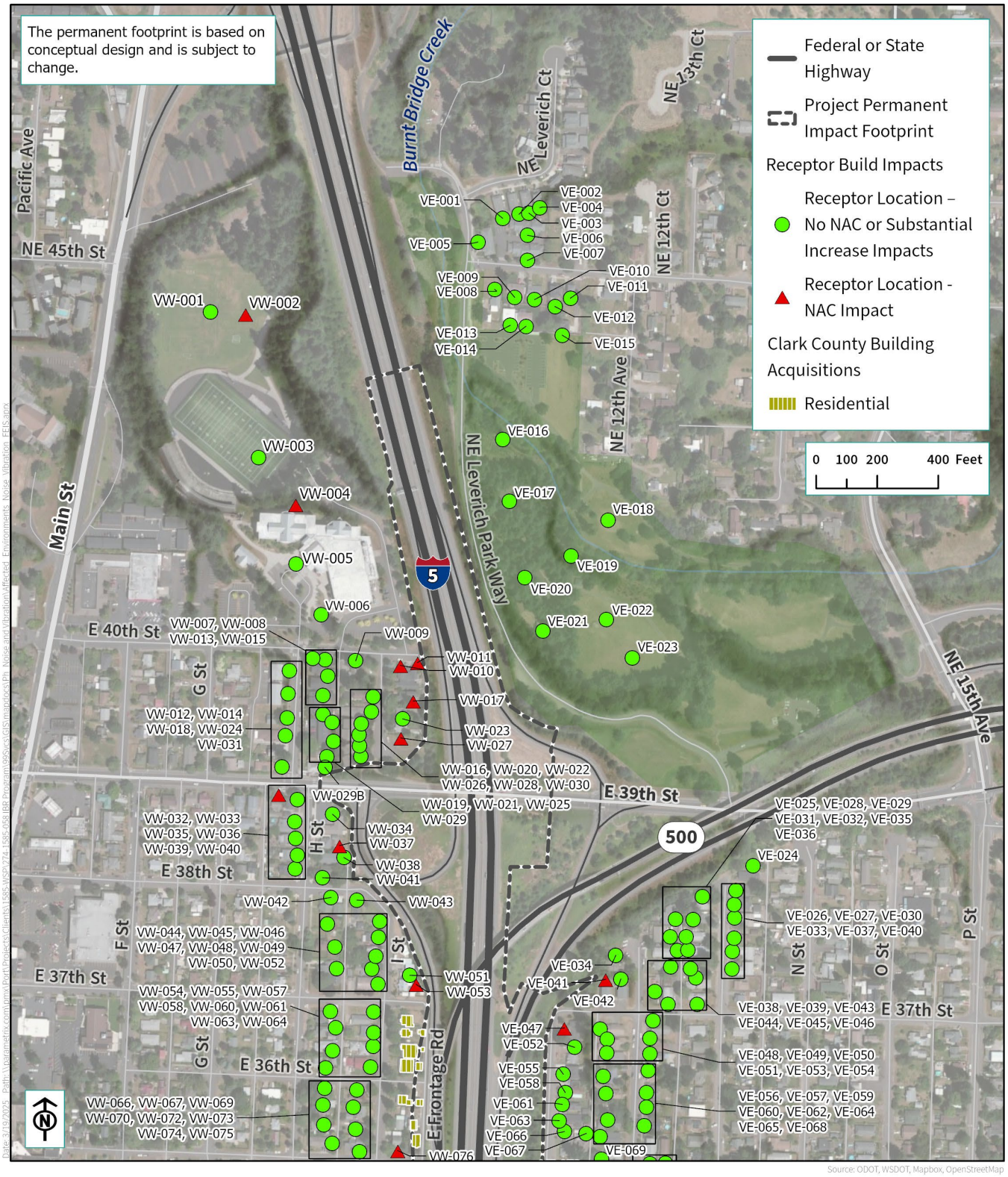


Figure 3.11-11. Modified LPA with Recommended Design Options – 2045 Traffic Noise Impacts – E 30th Street to E 39th Street

Figure 3.11-12. Modified LPA with Recommended Design Options – 2045 Traffic Noise Impacts – E 39th Street to Terminus



Downtown Vancouver

In downtown Vancouver, traffic noise levels under the Modified LPA with the single-level fixed-span bridge configuration with one auxiliary lane (Recommended Design Options) would approach or exceed the WSDOT NAC at the same 26 multifamily residences, kindergarten school at Providence Academy, and three trails as existing conditions along with one outdoor use space for Providence Academy offices, and at an additional eight residences—three more than the No-Build Alternative. Traffic noise levels would approach or exceed the NAC at one office. Noise levels would range from 51 to 73 dBA L_{eq}, with noise levels within 1 dBA of existing conditions at most locations, and within a range of -1 to 6 dBA compared to existing noise levels where roadway alignment shifts closer to or further from noise receptor locations. At one undeveloped property along Columbia Street (DT-049), noise levels would be 11 dBA higher than existing conditions.

Noise levels resulting from the Modified LPA with Recommended Design Options would be within 3 dBA of No-Build Alternative noise levels at most locations. Where roadways would be closer to or further from noise receptor locations, the change in traffic noise levels would range from -8 to 9 dBA compared to the No-Build Alternative. The highest noise levels under the Modified LPA with Recommended Design Options would be 73 dBA L_{eq}, predicted to occur outside a building used as office and commercial space (DT-019) located north of E Evergreen Boulevard. In downtown Vancouver, no substantial noise level increases would occur. Figure 3.11-8 and Figure 3.11-9 show the location of each traffic noise impact under the Modified LPA with all design options.

The elimination of C Street ramps design option at the SR 14 interchange would result in a minor change in traffic noise levels below the common threshold of human hearing (0 to 2 dBA). This difference is due to the removal of these roadways, which would shift traffic to other roadways in the area.

The I-5 westward shift design option would also shift traffic noise to the west but would result in a barely perceptible increase (2 to 3 dBA) in traffic noise levels west of I-5 near the southbound mainline and ramps. The I-5 westward shift design option would require two additional acquisitions located east of C Street between E 7th Street and E 8th Street. One of these buildings houses commercial businesses, including a restaurant (DT-025), a theater, and a salon, and the other is an apartment building (DT-027). The centered I-5 mainline design option would result in traffic noise levels above the impact criteria at the apartment building, while the design option to shift the I-5 mainline west would acquire this noise-sensitive land use and thus exclude it from the total number of noise impacts.

The single-level movable-span bridge configuration design option would have the same effects and result in similar traffic noise levels as the single-level fixed-span bridge configuration design option because there would be no substantial change in the line-of-sight from the bridge deck to the nearest noise-sensitive receptors and there would be no substantial change in traffic volumes, speeds, and vehicle mix. For the double-deck fixed-span bridge configuration design option, users on the shared-use path across the new Columbia River bridges would have more shielding and less exposure to noise from highway vehicles.

The Modified LPA with two auxiliary lanes would not result in differing impacts than the Modified LPA with one auxiliary lane due to the distance from traveling lanes to the nearest noise-sensitive receptors remaining nearly identical and no substantial change in traffic volumes, speeds, and vehicle mix.

Fort Vancouver

Long-term reasonably foreseeable effects on noise levels would not differ among the Modified LPA design options in Fort Vancouver. The Modified LPA would result in the same WSDOT NAC exceedances as the No-Build Alternative at Fort Vancouver trails, one Fort Vancouver Historic Village site, and one of four offices. In the VNHR, noise levels would be above the WSDOT NAC at two residences and four total office buildings, each of which contains multiple tenants. Noise levels would range from 53 to 75 dBA L_{eq}, with a decrease of 1 dBA below existing conditions at Old Apple Tree Park and nearby trail and an increase of up to 9 dBA over existing

conditions at one Fort Vancouver office, represented by site FV-004. Compared to the No-Build Alternative, traffic noise levels under the proposed Modified LPA are expected to increase throughout much of the Fort Vancouver area, with an increase of 8 dBA at two sites—site FV-004 and FV-046—and decrease by as much as 3 dBA at two sites represented by site FV-039 and FV-049. Sites FV-004 and FV-046 represent a historic district office and historic district trail respectively. Sites FV-039 and FV-049 represent Old Apple Tree Park and one location along the recreation trail south of the historic district, respectively. Figure 3.11-8 and Figure 3.11-9 show the location of each traffic noise impact in Fort Vancouver.

North Vancouver, East of I-5

Long-term reasonably foreseeable effects on noise levels would not differ among the Modified LPA design options in North Vancouver, east of I-5. In north Vancouver east of I-5, the Modified LPA would exceed the WSDOT NAC at 26 locations near the future I-5 alignment. The 26 locations include 26 of the 29 WSDOT NAC exceedances predicted under the No-Build Alternative (including 19 of the 23 exceedances at residences, one recreation area at Leverich Park and five of the six outdoor-use locations at Marshall Park). No substantial increase impacts are predicted under the Modified LPA.

Noise levels would range from 49 to 73 dBA L_{eq} and would fall within 1 to 3 dBA of existing conditions at most locations. Compared to existing conditions, noise levels would range from a decrease of 5 dBA below existing conditions to an increase of 3 dBA above existing conditions. Compared to the No-Build Alternative, traffic noise levels are expected to be within 1 dBA throughout much of this subarea, with only slight increases of 0 to 2 dBA at most locations. Noise reductions of up to 5 dBA are predicted at outdoor-use areas south of the Department of Veterans Affairs (VA) Hospital from the shift in the northbound I-5 off-ramp to Fourth Plain Boulevard. Figure 3.11-10, Figure 3.11-11, and Figure 3.11-12 show the location of each traffic noise impact in north Vancouver east of I-5.

North Vancouver, West of I-5

Long-term reasonably foreseeable effects on noise levels would not differ among the Modified LPA design options in North Vancouver, west of I-5. In north Vancouver, west of I-5, noise levels under the Modified LPA would exceed the WSDOT NAC at 54 locations, which is seven more NAC impacts than existing conditions and 11 fewer NAC impacts than the No-Build Alternative. The 54 exceedance locations with the Modified LPA include the sites with an exceedance under existing conditions and the No-Build Alternative, which include residences, Kiggins Bowl, and one outdoor location at Discovery Middle School. No NAC impacts are predicted with the proposed Modified LPA with the single-level fixed-span bridge configuration and one auxiliary lane design options at the two offices that experience NAC impacts under existing conditions or under the No-Build Alternative.

Noise levels at this location would range from 49 to 76 dBA L_{eq}. Increases in noise levels over existing conditions would range from 2 to 12 dBA at residences between E 33rd Street and E 39th Street, where the I-5 southbound on-ramps would be shifted west (closer to residences). In this area, seven single-family homes would be displaced between E 35th Street and E 37th Street. Displaced residences are represented by modeled sites VW-056, VW-059, VW-062, VW-065, VW-068, VW-071, and VW-077. In this area, the Modified LPA with the single-level fixed-span bridge configuration and one auxiliary lane design options would result in fewer sites predicted to experience increases in noise than the No-Build Alternative due to the seven displaced residences.

A 2 to 4 dBA increase in noise levels over existing conditions is predicted at most locations in this area. Compared to the No-Build Alternative, noise levels with the Modified LPA with the single-level fixed-span bridge configuration and one auxiliary lane design options would be within 1 dBA at most locations and would have similar increases of up to 10 dBA at residences near the ramp improvements between E 33rd Street and E 39th Street. Six residences located between E 33rd Street and E 35th Street are predicted to undergo

substantial noise impacts. The six residences are represented by five modeled sites: VW-080, VW-082, VW-084, VW-094, and VW-098. Figure 3.11-10, Figure 3.11-11, and Figure 3.11-12 show the location of each traffic noise impact in north Vancouver west of I-5.

Portland Light-Rail Noise

The only noise-sensitive land use between the existing light-rail terminus at the Expo Center and the Oregon-Washington state line is several rows of floating homes in North Portland Harbor. The Modified LPA, with any of the design options, would require relocation of the first row of homes and one home on the second dock; therefore, those homes were not analyzed for noise impacts. Light-rail noise was analyzed at the nearest remaining homes based on the distance between the proposed tracks and the homes. In all, 36 homes on the west side of the proposed North Portland Harbor and Columbia River bridges were evaluated for light-rail noise. The 36 homes were represented by modeling sites PD-070 to PD-075, PD-077 to PD-095, PD-103 to PD-108, and PD-125 to PD-129 (shown on Figure 3-5 of the Noise and Vibration Technical Report, as listed in Appendix H). The existing L_{dn} for the homes was extrapolated from measured data and on-site inspections.

The analysis predicted noise levels below the FTA noise impact criteria under the Modified LPA with the single-level fixed span bridge configuration and one auxiliary lane design options, including at the nearest remaining floating homes in North Portland Harbor. At all other noise-sensitive properties in the Portland portion of the project area, noise from light-rail operations would be well below the traffic noise levels, including the manufactured home residential area along the Columbia River. The predicted noise levels at receptor LRT-3 would be less than 1 dB because the train noise would be more than 10 dB lower than the existing ambient levels. Results at the floating homes in North Portland Harbor are shown in Table 3.11-8 under site LRT-3. Noise screening distances referenced in the following sections are from The FTA Noise and Vibration Impact Assessment Manual, Tables 4-7 and 4-8.

Portland Transit Station Noise

The analysis reviewed the noise-sensitive receptors located nearest to the station improvements under the proposed Modified LPA (with all design options), following the FTA's guidance for noise-screening distances of 200 feet unobstructed and 100 feet with intervening buildings from the Expo Center Station and Hayden Island Station. The nearest noise-sensitive receptor to the Expo Center Station was over 500 feet and over 1,000 feet from the Hayden Island Station. FTA's noise-screening distances of 1,000 feet unobstructed and 650 feet with intervening buildings was applied to the Expo Center Overnight Station. The nearest noise-sensitive receptor to the Expo Center Overnight Station was over 1,000 feet and included intervening buildings between the site and the receptor located along the Columbia River. Since the nearest noise-sensitive receptors were located beyond the FTA noise-screening distance at each of the transit stations in Portland, no quantitative noise analysis was performed.

Ruby Junction Light-Rail OMF

The planned expansion of the Ruby Junction Light-Rail OMF is 350 feet from the nearest homes on SE 202nd Avenue, which is located within the FTA noise-screening distance. Modeled noise levels at the nearest home that would result from overall maintenance yard improvements are predicted to be below the FTA moderate and severe impact criteria. Results are shown in Table 3.11-8 under site "OMF-1."

The other noise-sensitive land uses located closest to improvements at Ruby Junction Light-Rail OMF are single-family residences at SE 196th Avenue and residences at the Mobile Park Plaza at 19776 SE Stark Street. Both noise-sensitive use areas are located beyond the FTA noise-screening distance from the planned improvements. Therefore, noise impacts are not evaluated at either location.

C-TRAN Bus Maintenance Facility

The planned improvements to the C-TRAN Bus Maintenance Facility are over 600 feet from the nearest noise-sensitive receptor, a daycare at 6511 E 18th Street in Vancouver. FTA's noise-screening distances of 350 feet unobstructed and 225 feet with intervening buildings from bus storage and maintenance facilities was used. Parking improvements associated with the facility are located 230 feet from the daycare, which includes an intervening building. FTA's noise screening distance for parking improvements with intervening buildings is 75 feet. The nearest receptor is located beyond the FTA noise screening distances for planned improvements; therefore, noise impacts were not evaluated at this location.

Modeled Transit Noise and Vibration Effects

Downtown Vancouver Light-Rail Noise

The Modified LPA (all design options) would have moderate noise impacts at one location between the southern Columbia River bridge landing and W 6th Street—modeled site LRT-1 (the Normandy Apartments located at 316 E 7th Street). These impacts would result from special track work (i.e., turnouts, crossovers, switches). Noise levels with light-rail operations at this location are predicted to be 67 dBA L_{dn}. The criterion for moderate impacts at site LRT-1 is 66 dBA L_{dn}. Therefore, moderate noise impacts are predicted at this location for all design options except the I-5 westward shift design option which includes acquisition of the impact location.

Downtown Vancouver Transit Station Noise

The FTA noise-screening distances (200 feet unobstructed and 100 feet with intervening buildings) were used to review the nearest noise-sensitive receptors to station improvements included in the proposed Modified LPA (with all design options): Evergreen Station and Waterfront Station. The nearest noise-sensitive receptor to the Evergreen Station was the Vancouver Community Library located 250 feet away. The nearest noise-sensitive receptor to the Waterfront Station was apartments at 400 Washington Street located 600 feet away. The nearest noise-sensitive receptors were located beyond the FTA noise-screening distance at each of the Vancouver Transit Stations; therefore, noise impacts were not evaluated at either location.

Downtown Vancouver Park-and-Ride Noise

Park and rides in downtown Vancouver were reviewed against the FTA noise-screening distances. The nearest noise-sensitive receptors to park-and-rides 1a and 1c, located near the planned Waterfront Station (175 feet and 400 feet from apartments at 400 Washington Street), and park-and-ride 2a, located near the planned Evergreen Station (150 feet from Vancouver Community Library), are located beyond FTA noise-screening distances (125 feet unobstructed and 75 feet with intervening buildings). Therefore, noise impacts were not evaluated at these locations.

Downtown Vancouver park-and-ride 1b, at W 4th Street and Columbia Street, is located within the FTA noise-screening distance from the new apartments under construction at 400 Washington Street (shown as "PNR-1" on Table 3.11-8). Modeled noise levels that would result from park-and-ride 1b are predicted to be below the FTA moderate and severe impact criteria. Therefore, no noise impacts are predicted at 400 Washington Street. The park-and-ride 2b at C Street and E 7th Street is located within the FTA noise-screening distance from the Normandy Apartments located at 316 E 7th Street and the Econo Lodge located at 601 Broadway Street (shown as "PNR-2" on Table 3.11-9). Modeled noise levels that would result from park-and-ride 2b are predicted to be below the FTA moderate and severe impact criteria; therefore, no noise impacts are predicted at either location. Results are shown in Table 3.11-8.

Traction Power Substation (TPSS)

A planned TPSS site is included in the proposed Modified LPA (with all design options) to support transit power requirements. The site would be in WSDOT right-of-way alongside I-5, located just east of C Street and south of E 7th Street in downtown Vancouver. The proposed location of the TPSS in Vancouver is fully enclosed inside an ancillary equipment building located 100 feet from the Econo Lodge at 601 Broadway and the Normandy Apartments. The noise levels from the TPSS operations would not be noticeable at the nearest receptor location as all noise-producing equipment would be located inside the concrete block building. In addition, existing background traffic noise was measured at 74 dBA L_{eq} near the Normandy Apartments, located just north of the TPSS site. Long-term measurement data for this site, LT-2 can be found in Table 2-11 of the Noise and Vibration Technical Report (as listed in Appendix H). Due to the enclosure of noise-producing equipment and existing ambient conditions, noise from the TPSS site at the nearest receptor would be below the existing background traffic noise and would be less than FTA impact criteria.

Downtown Vancouver Total Transit Noise

Total transit noise was evaluated to identify any additional impact locations that weren't identified when evaluating individual noise sources. Impacts and calculated noise levels presented in Table 3.11-8 include noise from all Modified LPA (with all design options) transit improvements. Calculated noise levels are unchanged from individual noise levels due to the distance from stationary noise sources from sites located near the light-rail alignment. However, all noise levels are influenced by highway noise, which is included in the evaluation of mitigation measures presented in Section 3.11.6.

Downtown Vancouver Combined Highway and Transit Noise

LRT-1 is the one location where highway noise and transit noise impacts result from the proposed Modified LPA (with all design options). Since traffic noise is within 1 to 2 dBA of transit noise of 69 dBA in areas closest to I-5, the noise level from both sources could be 1 to 2 dB higher during the peak traffic hour of the day at this location. See Section 7.8.1 of the Noise and Vibration Technical Report (as listed in Appendix H) for additional information.

Portland Light-Rail Vibration

Sites sensitive to vibration were reviewed, along with the location of transit improvements, to identify potential vibration impacts. The one area that includes sites sensitive to vibration near transit improvements is the area of floating homes located near the proposed light-rail bridge from the Portland mainland to Hayden Island. Because these homes are located on water, minimal transmission of vibration is expected, and no impacts are predicted. The other transit facilities included in the proposed Modified LPA (with all design options) located in and around Portland are Hayden Island Station, Expo Center Station, Expo Center Overnight Station, and the Ruby Junction Light-Rail OMF, located in Gresham. As no vibration-sensitive sites are located in close proximity to these sites, no impacts are predicted. Therefore, no transit-related vibration impacts are predicted in the Portland area.

Table 3.11-8. Modified LPA with Recommended Design Options L_{eq} and L_{dn} for Transit Operations

Receptor [a]	Area Description [b]	Land Use [c]	Number of Units [d]	Existing Noise [e] (dBA)	Modified LPA Primary Transit Noise Source	Modified LPA Noise Contribution [f] (dBA)	FTA Impact Criteria [g]		Units with Impacts [h]	
							Moderate (dBA)	Severe (dBA)	Moderate	Severe
LRT-1	E 7th Street/E C Street	MF	12	83	Light-Rail	67	66	76	12[i]	–
LRT-2	E 6th Street/ E C Street	Hotel	0	80	Light-Rail	65	66	76	–	–
LRT-3	Jantzen Beach Floating Homes	SF	5	77	Light-Rail	65	66	76	–	–
OMF-1	SE 202nd Avenue (Gresham)	SF	3	61	Ruby Junction Light-Rail OMF	56	59	64	–	–
PNR-1	400 Washington Street	MF	200	68	Park-and-Ride 1b	61	63	73	–	–
PNR-2	E 7th Street/ E C Street	MF	12	83	Park-and-Ride 2b	61	66	76	–	–
	E 6th Street/ E C Street	Hotel	0	80	Park-and-Ride 2b	61	66	76	–	–

Sources: FTA Noise Impact Assessment Spreadsheet, 2018.

a Receptors with impacts shown on Figure 3.11-22.

b General description of the area of analysis.

c Land Use: SF = single-family; MF = multi-family; Hotel = hotel/motel.

d Number of individual apartments or homes affected.

e Existing noise levels in L_{dn} for category 2 land use, or L_{eq} for category 1 or 3 land uses.

f Noise from operation of the Modified LPA transit source only. This is the noise level used to determine impacts with the FTA criteria. Levels in **bold** exceed FTA criteria.

g FTA Impact Criteria.

h Number of units adversely affected by transit noise with Modified LPA.

i Impacts at LRT-1 would occur under all design options except the I-5 westward shift design option due to property acquisition.

dBA = A-weighted decibels; FTA = Federal Transit Administration; L_{dn} = day-night equivalent sound level; L_{eq} = equivalent sound level; LPA = Locally Preferred Alternative; OMF = Operation and Maintenance Facility

Downtown Vancouver Light-Rail Vibration

Vibration levels at the Normandy Apartments (LRV-1) and the mixed-use building at 801 C Street that includes the Regal City Center Cinema (LRV-2) are predicted to exceed the FTA vibration criteria due to the close proximity of special trackwork to each building. Maximum vibration levels at these sites could reach 77 to 81 VdB as shown in Table 3.11-9. The ground-borne vibration levels are due to trains passing over special trackwork near the receptors. Vibration levels at the Econo Lodge hotel at 601 Broadway (LRV-4) are predicted to be below the FTA vibration impact criteria. Figure 3.11-13, at the end of this section, provides an aerial view of this area and identifies the grouping of the homes and location of the proposed light-rail alignment. The Modified LPA with the I-5 westward shift design option would result in higher vibration levels in downtown Vancouver due to the westward shift of the light-rail alignment; however, no vibration impacts are anticipated due to the distance to sensitive receptors, because this design option includes acquisition of the affected locations (Normandy Apartments and Regal City Center Cinema).

Table 3.11-9. Projected Transit Vibration Effects under the Modified LPA

Receptor [a]	Area Description [b]	Land Use	FTA Vibration Criteria [c] (VdB)	Vibration Level [d] (VdB)	Meets Criteria [e]	Number of Impacts [f]
LRV-1	Normandy Apartments	MF	72	77	N	12[g]
LRV-2	E 8th Street/E C Street	Movie Theater	75	81	N	1 - Movie Theater[g]
LRV-3	Hayden Island Floating Homes	SF	72	See note [h]	See note [h]	See note [h]
LRV-4	Econo Lodge, 601 Broadway	Hotel	72	70	Y	-

a Receptors with impacts shown on Figure 3.11-13 and Figure 3.11-15 through Figure 3.11-22.
b General description of the area of analysis.
c FTA vibration impact criteria.
d Predicted vibration level.
e Amount the predicted level exceeds the criteria.
f Number of individual structures affected.
g Impacts at LRV-1 and LRV-2 would occur under all design options except the I-5 westward shift design option due to property acquisitions.
h Because these SF residences are on water, minimal transmission of ground vibration occurs.
FTA = Federal Transit Administration; MF = multifamily; SF = single family; VdB = vibration decibels; "-" = no impact

No transit-related vibration impacts are predicted in the Portland area. In Vancouver under all design options except the I-5 westward shift design option, vibration impacts would affect 12 residences at the Normandy Apartments (LRV-1) and a multi-use building at 801 C Street that includes a cinema and commercial businesses (LRV-2) shown in Figure 3.11-13.

Figure 3.11-13. Modified LPA - Downtown Vancouver Transit Noise and Vibration Analysis and Impacts

3.11.4 Temporary Reasonably Foreseeable Effects

Temporary reasonably foreseeable effects on noise and vibration were assessed for the noise and vibration study area, defined in Section 3.11.2, and the temporal scope described in the Chapter 3 introduction. No-Build Alternative

Under the No-Build Alternative, there would be no construction of replacement bridges, no removal of existing bridge, and none of the other proposed roadway, transit, or stormwater improvements associated with the Modified LPA. Because no IBR Program improvements are included in the No-Build Alternative, short-term effects would be limited to noise-sensitive land uses near ongoing maintenance activities.

Modified LPA

Construction Activities

Temporary reasonably foreseeable effects on noise and vibration would not differ among the Modified LPA design options. Construction of the new Columbia River bridges, removal of the existing Interstate Bridge, and improvements to interchanges, local roads, and various transit facilities would require equipment and machinery common to roadway, transit, bridge, and structural projects. Table 3.11-10 provides a list of the typical types of equipment used for this kind of construction, the corresponding activities, and the maximum noise levels as measured at 50 feet from the noise source under normal use.

Table 3.11-10. Typical Construction Equipment, Use, and Reference Maximum Noise Level

Equipment	Typical Expected Project Use [a]	L_{max} [b]	Source [c] (Sources described in Table footnotes)
Air Compressors	Used for pneumatic tools and general maintenance - all phases	70–76	a, b, c
Backhoe	General construction and yard work	78–82	b, c
Backhoe	General construction and yard work	78–82	b, c
Concrete Pump	Pumping concrete	78–82	b, c
Concrete Saws	Concrete removal, utilities access	75–80	b, c
Crane	Materials handling, removal, and replacement	78–84	b, c
Excavator	General construction and materials handling	82–88	b, c
Forklifts	Staging area work and hauling materials	72	a, b, c
Haul Trucks	Materials handling, general hauling	86	b, c
Jackhammers	Pavement removal	74–82	b, c
Loader	General construction and materials handling	86	b, c
Pavers	Roadway paving	88	b
Pile Drivers	Support for structure and hillside	99–105	b, c
Power Plants	General construction use, nighttime work	72	b, c
Pumps	General construction use, water removal	62	b, c
Pneumatic Tools	Miscellaneous construction work	78–86	c
Service Trucks	Repair and maintenance of equipment	72	b, c
Tractor Trailers	Material removal and delivery	86	c
Utility Trucks	General project work	72	b
Vibratory Equipment	Shore up hillside to prevent slides and soil compacting	82–88	b, c
Welders	General project work	76	b, c

Sources: FTA 1995, 2018

a Typical maximum noise level under normal operation as measured at 50 feet from the noise source.

b Maximum noise level as measured at a distance of 50 feet under normal operation.

c Sources of noise levels presented:

Portland, Oregon Area Projects: Light-rail, I-5 Preservation, and Hawthorne Bridge construction projects and other measured data.

U.S. Department of Transportation construction noise documentation and other construction noise sources.

Construction Noise

The Modified LPA would be completed in the following four typical construction phases.

Preparation

Major noise-producing equipment used during the preparation stage could include concrete pumps, cranes, excavators, haul trucks, loaders, and tractor trailers. During this phase, maximum noise levels could reach 82 to 94 dBA at the nearest residences (50 to 100 feet) for normal construction activities.

Other major noise sources that may be required include the use of vibratory and impact equipment to install piles or sheet piles. Other equipment expected during this phase includes backhoes, air compressors, forklifts, pumps, power plants, service trucks, and utility trucks.

Construction

Construction impacts would persist at the construction site, and temporary noise impacts would occur at various times throughout construction and demolition over approximately a 9- to 15-year construction period. The loudest noise sources during construction of the new bridges would be pile drivers, cement mixers, concrete pumps, pavers, haul trucks, and tractor trailers. Drilled shafts would be used to reduce the number of piles driven. The cement mixers and concrete pumps would be required for construction of the superstructure. Maximum noise levels would range from 82 to 94 dBA at the closest receiver locations.

Approximately 3,311 temporary piles would be installed and removed during the multiyear construction of the Columbia River and North Portland Harbor bridges. These piles would be staged throughout the in-water construction and demolition periods. Between 100 and 400 temporary piles could be in the water at a given time.

An average of six temporary, load-bearing piles could be installed per day using one or two impact drivers. Some amount of impact pile driving in the Columbia River or North Portland Harbor would occur on approximately 735 days spread over the estimated six in-water work windows that would be required for the construction of the Columbia River bridges.

Three hundred impact strikes could be required to finish driving or proofing a given pile. This number of strikes would require approximately 30 to 45 minutes of impact hammer activity. Between two and three piles per day could be installed or proofed with an impact hammer, with an estimated total maximum number of 900 impact strikes per day if a single impact pile driver is in operation, or up to 1,800 impact strikes per day if two pile-driving rigs are operated concurrently. Actual pile production rates vary, and a typical day would likely have fewer strikes.

A bubble curtain or similarly effective noise attenuation device would be implemented during all impact pile driving, and a hydroacoustic monitoring plan would be implemented during impact pile driving to confirm the level of attenuation provided. This monitoring program would require unattenuated pile strikes in order to confirm the amount of attenuation provided by the system. Up to 75 unattenuated strikes could be required to accomplish this testing. Testing would occur up to approximately 40 days total over the course of construction. On each day of testing, unattenuated pile strikes would occur over a period of less than 10 minutes.

During construction, up to two impact pile drivers could operate simultaneously near one another. In addition, the contractor could elect to have both a vibratory and impact pile-driving rig in operation simultaneously. Operation of two pile-driving rigs simultaneously is not expected to produce greater decibel levels. Pile strikes from both drivers would need to be synchronous (within 0.0 and approximately 0.1 seconds apart) to produce higher noise levels than a single pile driver operating alone. Because this level of synchronicity is highly unlikely, the analysis assumes that pile drivers would not generate noise levels greater

than that of a single pile driver. Refer to Section 3.16, Ecosystems, for additional information regarding construction noise impacts to underwater species.

The Modified LPA with any of the design options would result in temporary impacts to noise levels associated with construction of the Columbia River bridges and associated roadway and interchange improvements. The extent and nature of these impacts would be minimized and avoided to the extent possible through the implementation of best management practices (BMPs), such as implementing a bubble curtain (or similarly effective noise attenuation device) during all in-water impact pile driving.

Miscellaneous Activities

General construction activities would occur after completion of the heavy construction and would include installation of bridge railings, signage, lighting, roadway striping, and others. As shown in Table 3.11-11, many of these activities are expected to produce noise levels above 80 dBA at 50 feet for extended periods of time.

Demolition

Demolition of the existing structures would require heavy equipment such as concrete saws, cranes, excavators, hoe-rams, haul trucks, jackhammers, loaders, and tractor trailers. Maximum noise levels could reach 82 to 93 dBA at the nearest receptors.

Table 3.11-11 provides the noise levels for each of the four typical construction phases as measured at 50 feet from the construction activity. The noise levels shown in Table 3.11-11 are the typical maximums and would only occur periodically during the heaviest periods of construction. Actual hourly noise levels could be substantially lower than those stated, depending on the level of activity at that time and the distance from the work site to the noise-sensitive properties.

Table 3.11-11. Noise Levels for Typical Construction Scenarios at 50 Feet from Work Site

Scenario [a]	Equipment [b]	L_{max} [c] (dBA)	L_{eq} [d] (dBA)
Preparing for construction of new structures.	Air compressor, backhoe, concrete pump, crane, excavator, forklift, haul truck, loader, water pump, power plant, service truck, tractor trailer, utility truck, and vibratory equipment	94	87
Constructing new structures and paving roadways.	Air compressor, backhoe, cement mixer, concrete pump, crane, forklift, haul truck, loader, paver, pump, power plant, service truck, tractor trailer, utility truck, vibratory equipment, and welder	94	88
Conducting miscellaneous activities, including striping, lighting, and providing signs.	Air compressor, backhoe, crane, forklift, haul truck, loader, pump, service truck, tractor trailer, utility truck, and welder	91	83
Demolishing existing structures.	Air compressor, backhoe, concrete saw, crane, excavator, forklift, haul truck, jackhammer, loader, power plant, pneumatic tools, water pump, service truck, and utility truck	93	88

Note: Combined worst-case noise levels for all equipment 50 feet from work site.

a Operational conditions under which the noise levels are projected.

b Normal equipment in operation under the given scenario.

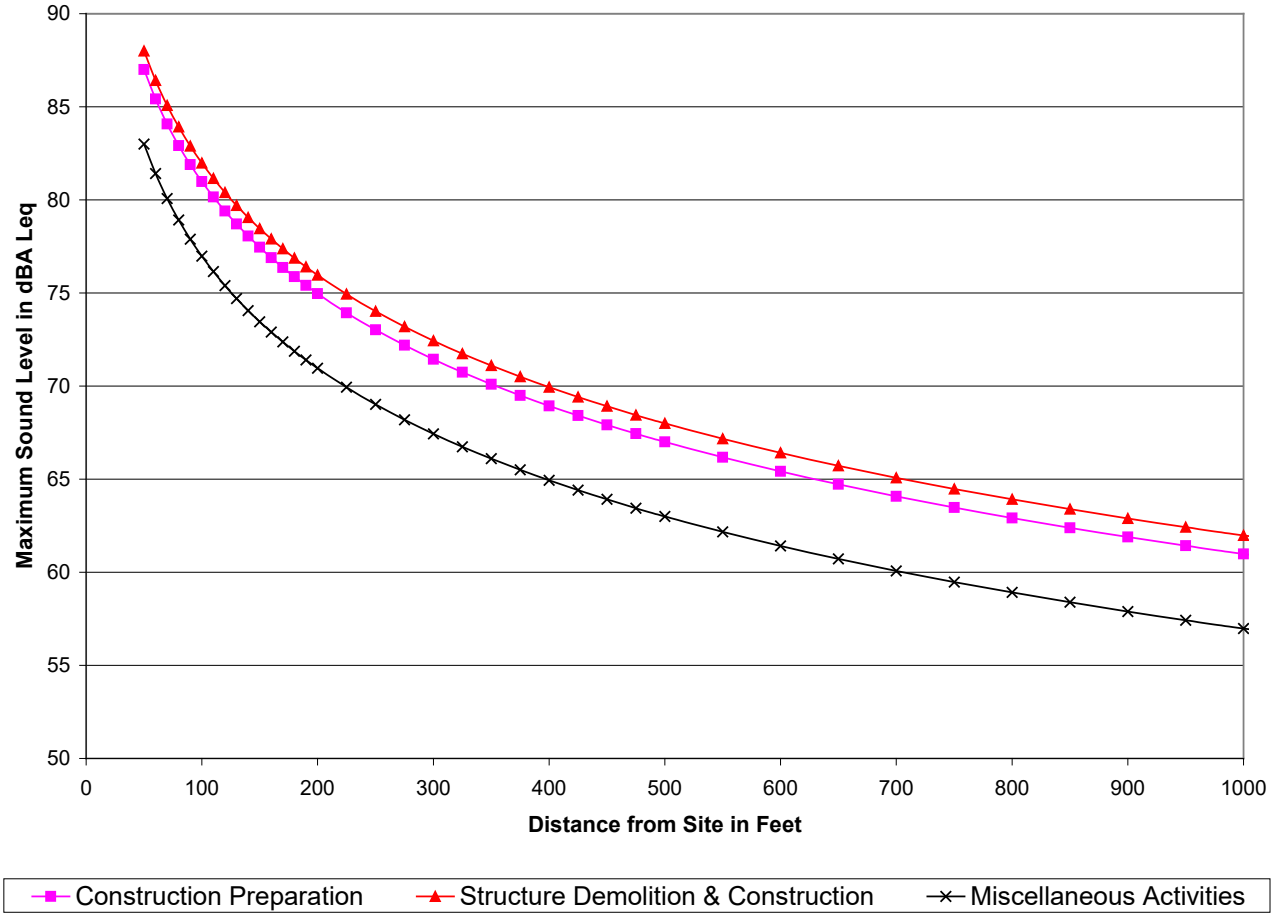
c L_{max} (dBA) is an average maximum noise emission for the construction equipment under the given scenario.

d L_{eq} (dBA) is an energy average noise emission level for construction equipment operating under the given scenario. For this type of equipment, the L_{eq} is approximately equal to the L_{50} (that is, noise level that is exceeded 50 percent of the time).

dBA = A-weighted decibels

The construction noise study assumed worst-case noise levels during each of the four general construction phases for periods of maximum construction activity. Actual noise levels experienced during construction would generally be lower than those described below. The information in Table 3.11-11 was used to predict construction noise levels for several distances from the project work area. Figure 3.11-14 is a graph of the construction noise level versus distance for the phases of project construction listed in Table 3.11-11.

Figure 3.11-14. Noise Level vs. Distance for Typical Construction Phases



Source: Noise and Vibration Technical Report

Construction Vibration

Major vibration-producing activities would occur primarily during preparation for the new bridges and demolition of the existing bridge. Activities that have the potential to produce high levels of vibration would include pile driving, vibratory shoring, soil compacting, and some hauling and demolition activities. Vibration effects from pile driving or vibratory sheet installations could occur within 50 to 100 feet of sensitive receivers. It is unlikely that vibration levels would exceed 0.5 inches per second peak particle velocity (approximate threshold for building damage) at distances greater than 100 feet from the construction sites. Although analysis indicates that buildings in the noise and vibration study area would not experience adverse vibration-related impacts from construction, owners of three historic structures (Barracks Post Hospital, Clark County Museum, and Providence Academy) have expressed concerns. See Section 5.1.2 of the Noise and Vibration Technical Report (as listed in Appendix H) for additional details on construction vibration. See Section 3.8, Cultural Resources, for further discussion of efforts to measure, monitor, and, if necessary, mitigate vibration impacts to these historic structures. As design of the proposed Modified LPA progresses and construction details are identified, a detailed construction noise and vibration assessment will be conducted.

The mitigation measures intended to protect marine life from pile-driving hydroacoustic impacts, as described in Section 3.16, Ecosystems, would also reduce the potential for noise and vibration impacts to nearby noise-sensitive land uses.

3.11.5 Intentionally Left Blank

3.11.6 Avoidance, Minimization, and Mitigation Measures

Long-Term Reasonably Foreseeable Effects

Highway Traffic Noise Mitigation

Mitigation related to highway traffic noise, including mitigation (abatement) measures that meet ODOT's and WSDOT's feasibility and reasonableness criteria, may be recommended for inclusion in the Modified LPA. Feasibility primarily deals with engineering considerations such as whether substantial noise level reductions can be achieved or whether there would be a negative effect on property access resulting from the placement of noise walls (WSDOT 2020). Reasonableness comprises three factors: (1) if abatement is cost-effective; (2) if abatement can achieve the design goal; (3) and if the abatement is desired by benefiting receptors (WSDOT 2020). The complete evaluation of potential traffic noise abatement measures can be found in Chapter 7 of the Noise and Vibration Technical Report (as listed in Appendix H), including discussion of isolated noise receptors where mitigation would not be reasonable.

Following ODOT and WSDOT traffic noise policies (ODOT 2011, WSDOT 2020), the following noise abatement measures were considered:

- Traffic management measures (for example, traffic control devices and signing for prohibition of certain vehicle types, time-use restrictions for certain vehicle types, modified speed limits, and exclusive land designations).
- Highway design measures (for example, alteration of horizontal/vertical alignments).
- Acquisition of property rights (either in fee or lesser interest) for construction of noise barriers.
- Acquisition of real property or interests therein (predominantly unimproved property) to serve as a buffer zone to preempt development that would be adversely affected by traffic noise.
- Sound insulation of all Activity Category D land uses (Table 3.11-1), including public use or nonprofit institutional structures.
- Construction of sound barriers (including landscaping for aesthetic purposes), whether within or outside the highway right of way. Interstate construction funds may not participate in landscaping. The use of landscaping for noise abatement requires a minimum of 65 feet of densely planted, mature vegetation to provide a noticeable noise abatement up to 6 dB (NCHRP 2021).

Noise abatement by noise walls is the only abatement measure that was found to meet abatement criteria while maintaining normal traffic operations and IBR Program objectives for each impact area. Chapter 7 of the Noise and Vibration Technical Report (as listed in Appendix H) provides a description of how each abatement measure was considered.

Noise mitigation was evaluated at all locations where traffic noise impacts were predicted. Noise walls were evaluated to mitigate noise impacts at 16 locations in Washington and three in Oregon. Fourteen of the 16 noise walls in Washington (Noise Walls 1 through 9 and Noise Walls 11, 11A, 12, 14, and 15) were found to meet WSDOT criteria for the placement of a feasible noise wall. However, only 10 locations—Noise Walls 1 through 8, Noise Wall 11A, and Noise Wall 12—met WSDOT criteria for the placement of both a feasible and reasonable

noise barrier. Included in the 10 recommended noise walls, Noise Walls 2 through 8 and 11A would replace existing noise walls.

Two of the three noise walls evaluated in Oregon (Noise Walls 16 and 17) did not meet ODOT criteria for the placement of a feasible noise wall. The third noise wall evaluated in Oregon (Noise Wall 18) met ODOT criteria for the placement of both a feasible and reasonable noise barrier.

Noise mitigation results would be the same for the Modified LPA with all bridge configuration design options, one or two auxiliary lanes, and the SR 14 Interchange without C Street ramps. The only difference in highway traffic noise mitigation between the Modified LPA design options is that under the I-5 mainline shifted west design option, Noise Wall 12 would not be recommended because the noise-affected property would be acquired.

The 11 feasible and reasonable noise walls are listed below and described in Section 7.2.1.1 of the Noise and Vibration Technical Report (as listed in Appendix H). The general location of each feasible and reasonable noise wall is described below and shown on Figure 3.11-15 to Figure 3.11-21. Table 3.11-12 summarizes each noise wall evaluation.

- Noise Wall 1: west side of I-5 from the southbound on-ramp from Main Street to E 39th Street.
- Noise Wall 2: west side of I-5 between E 39th Street and E 33rd Street.
- Noise Wall 3: east side of I-5 between E 33rd Street and SR 500.
- Noise Wall 4: west side of I-5 between E 33rd Street and E 29th Street.
- Noise Wall 5: east side of I-5 between E 33rd Street and E 29th Street.
- Noise Wall 6: west side of I-5 between E 29th Street and E 26th Street/E Fourth Plain Boulevard.
- Noise Wall 7: east side of I-5 between E 29th Street and E Fourth Plain Boulevard.
- Noise Wall 8: west side of I-5 between E Fourth Plain Boulevard and E McLoughlin Boulevard.
- Noise Wall 11A: east side of I-5 between E Evergreen Boulevard and Officers Row.
- Noise Wall 12: west side of I-5 between E 7th Street and E 8th Street.
- Noise Wall 18: north side of N Marine Drive and east of I-5.

Table 3.11-12. Noise Wall Analysis Summary

Wall	No. of Impacts [a]	Length (feet)	Height (feet)	No. of Impacts Benefited [b]	Feasible?	Achieves Design Goal?	Total Benefits [c]	Planning Level Cost [d]	Cost Allowance / Cost per Benefited Receiver [e]	Cost Reasonable? [e]	Wall Recommended?
1	10	897	12	7	Yes	Yes	16	$555,530	$700,863	Yes	Yes
2	10	1,727	8	10	Yes	Yes	15	$712,631	$717,379	Yes	Yes
3	3	1,845	14	3	Yes	Yes	40	$1,333,086	$1,455,607	Yes	Yes
4	11	970	10	10	Yes	Yes	18	$500,617	$794,174	Yes	Yes
5	17	987	10	17	Yes	Yes	18	$509,391	$1,053,875	Yes	Yes
6	10	986	10	8	Yes	Yes	11	$508,875	$579,889	Yes	Yes
7	10	1,105	10	10	Yes	Yes	10	$570,291	$708,706	Yes	Yes
8	21	1,496	16	15	Yes	Yes	38	$1,235,337	$1,723,770	Yes	Yes
9	4	998	18	4	Yes	Yes	8	$927,122	$327,620	No	No
10	6	1,089	16	0	No	No	0	N/A	N/A	No	No
11	10	1,172	18	4	Yes	Yes	6	$1,088,765	$302,201	No	No
11A	4	464	6	3	Yes	Yes	3	$143,682	$146,985	Yes	Yes
12	6	540	10 to 12	6	Yes	Yes	6	$316,782	$322,044	Yes	Yes
13	24	497	12	4	No	No	4	N/A	N/A	No	No
14	4	942	8 to 20	4	Yes	Yes	5	$854,094	$229,767	No	No
15	8	1,050	14	3	Yes	Yes	3	$725,688	$150,494	No	No
16	5	3,124	24	0	No	N/A	0	N/A	N/A	No	No

Wall	No. of Impacts [a]	Length (feet)	Height (feet)	No. of Impacts Benefited [b]	Feasible?	Achieves Design Goal?	Total Benefits [c]	Planning Level Cost [d]	Cost Allowance / Cost per Benefited Receiver [e]	Cost Reasonable? [e]	Wall Recommended?
17	13	1,827	24	0	No	N/A	0	N/A	N/A	No	No
18	12	1,013	12 to 16	12	Yes	Yes	20	$423,300	$21,165	Yes	Yes

Notes: N/A = not applicable for walls that do not meet feasibility.
Noise Wall 12 would not be included in the I-5 westward shift design option due to program acquisitions at impact locations.
Details of all wall evaluations are presented in the Noise and Vibration Technical Report (as listed in Appendix H).

a Impacts based on WSDOT NAC, ODOT NAAC, and Substantial Increase thresholds with 2045 Modified LPA.

b Impacts benefited based on reduction from 2045 Modified LPA with existing noise walls in place.

c Total benefits based on reduction from 2045 Modified LPA without existing noise walls in place.

d Planning level cost calculated from WSDOT's planning level cost of $51.61 per square foot and ODOT's planning level cost of $30 per square foot for wall heights up to 16 feet and $37.50 per square feet for wall heights from 17 to 25 feet.

e WSDOT Cost allowance and ODOT wall cost per benefited receiver. Cost allowance for Noise Wall 18 is calculated only for ground-level or first-floor receivers.

f Cost reasonableness based on WSDOT Noise Policy Reasonableness guidelines and ODOT's Noise Manual Cost Effectiveness Criteria.

LPA = Locally Preferred Alternative; N/A = not applicable; NAAC = Noise Abatement Approach Criteria; NAC = Noise Abatement Criteria; ODOT = Oregon Department of Transportation; WSDOT = Washington State Department of Transportation

Figure 3.11-15. Modified LPA with Recommended Design Options – 2045 Evaluated Noise Walls – Portland Mainland

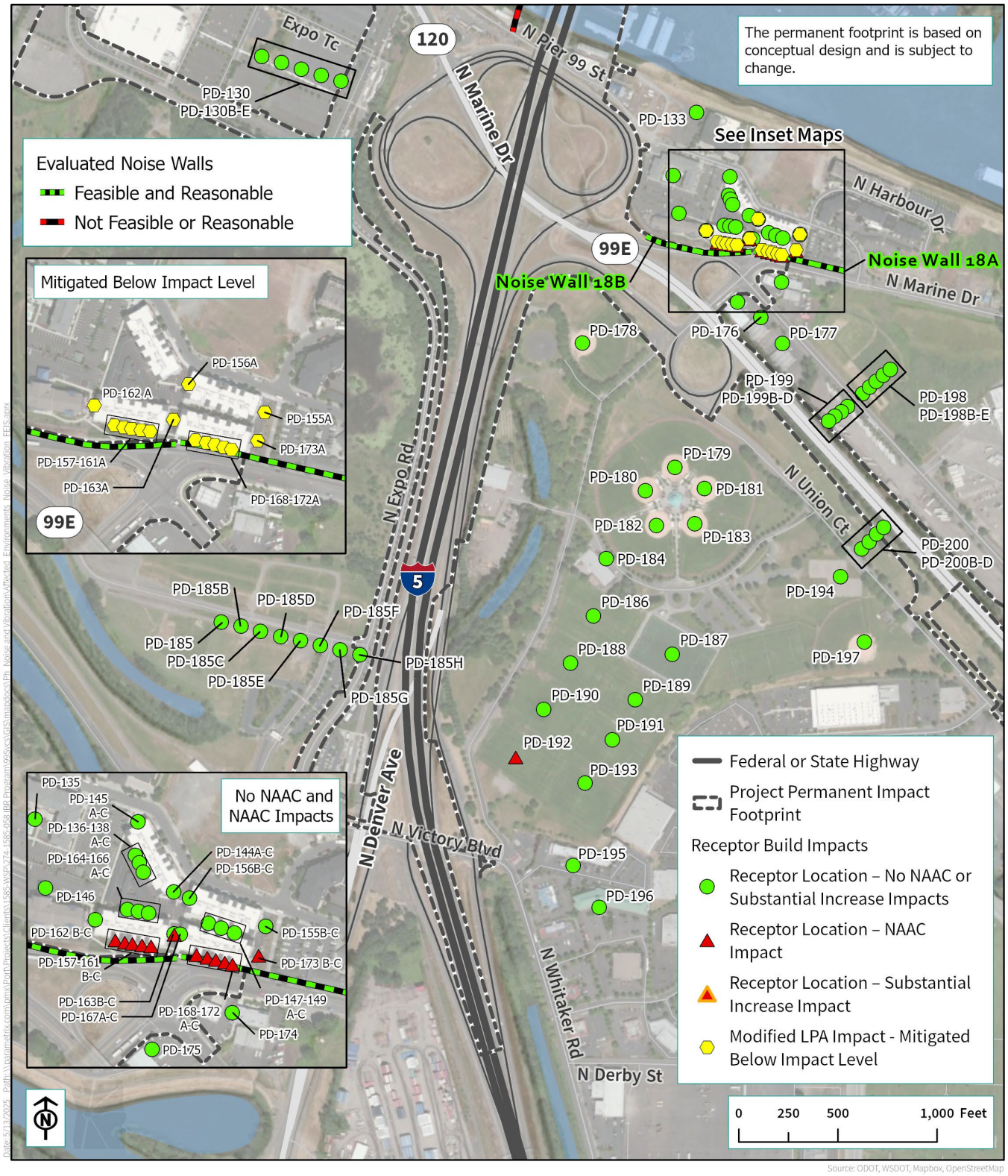


Figure 3.11-16. Modified LPA with Recommended Design Options – 2045 Evaluated Noise Walls – Portland/Hayden Island

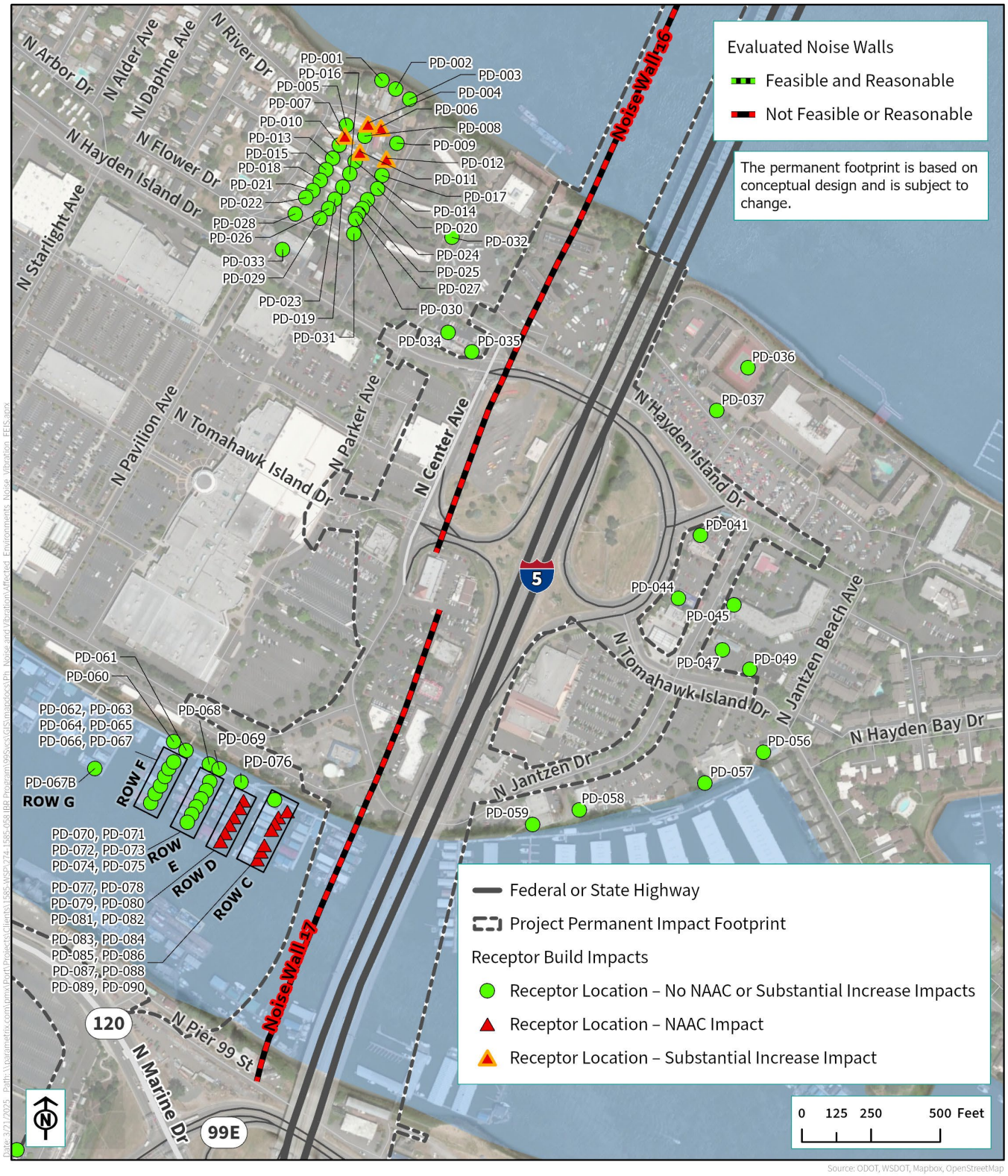


Figure 3.11-17. Modified LPA with Recommended Design Options – 2045 Evaluated Noise Walls – I-5/SR 14 Interchange

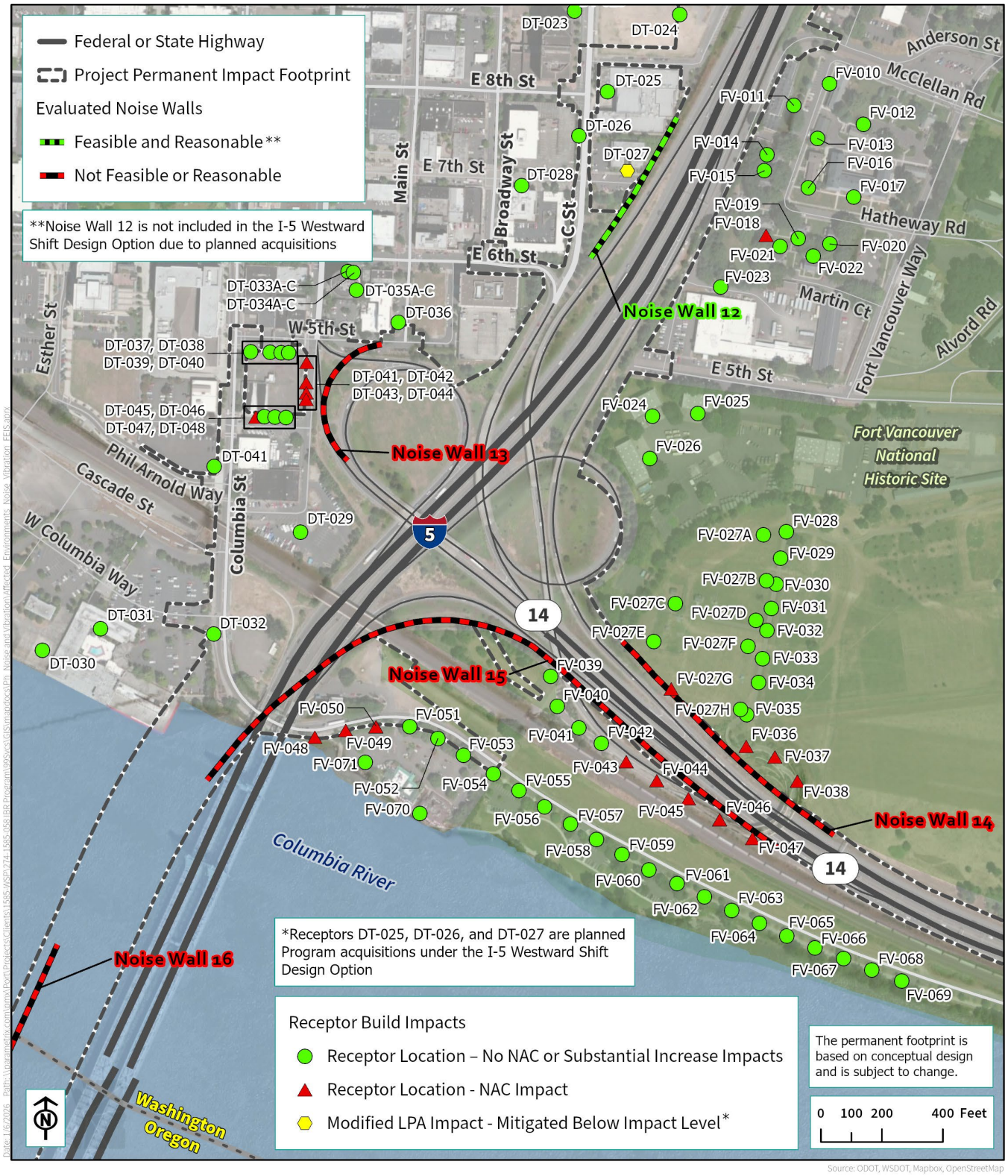


Figure 3.11-18. Modified LPA with Recommended Design Options – 2045 Evaluated Noise Walls – E 8th Street to McLoughlin Boulevard

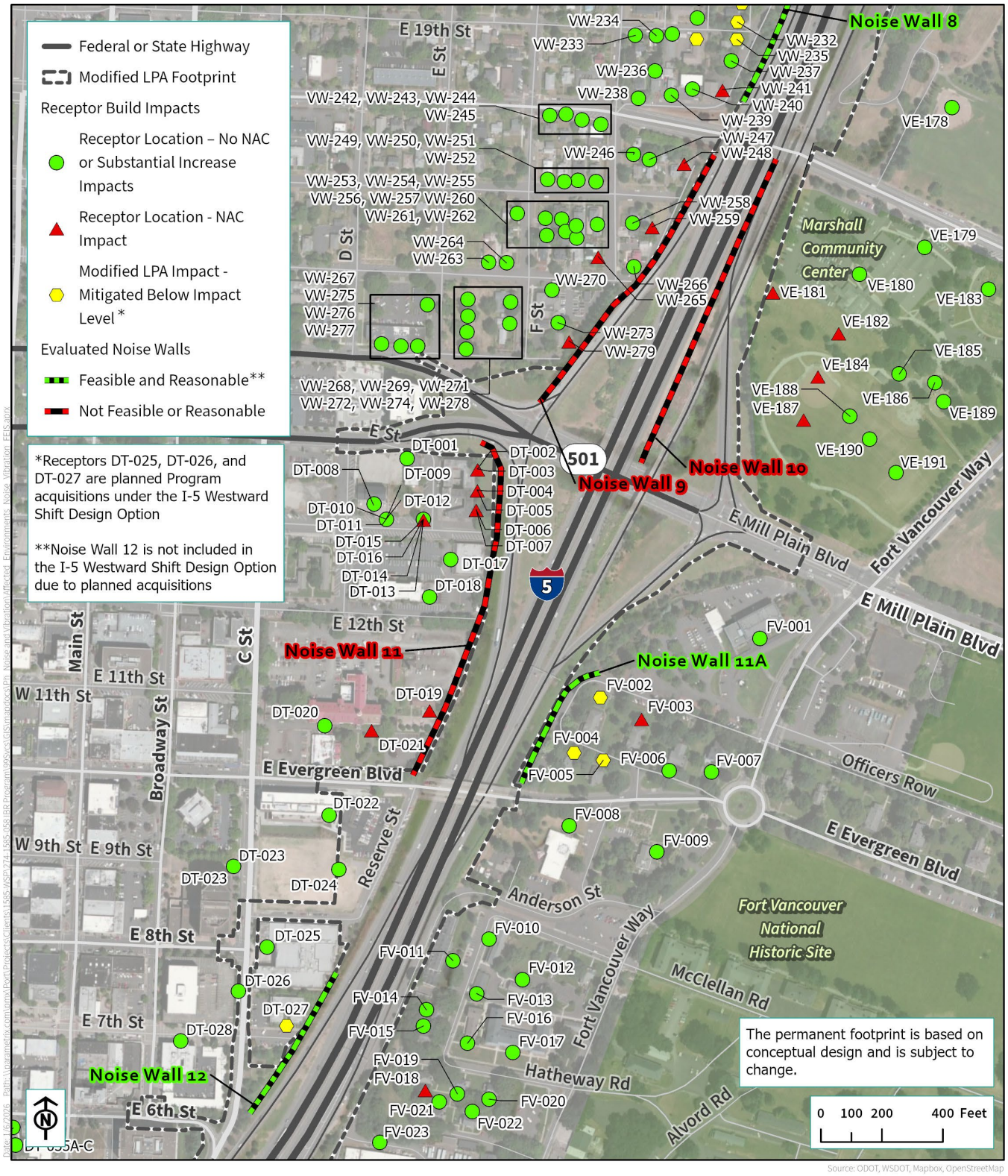


Figure 3.11-19. Modified LPA with Recommended Design Options – 2045 Evaluated Noise Walls – McLoughlin Boulevard to E 30th Street

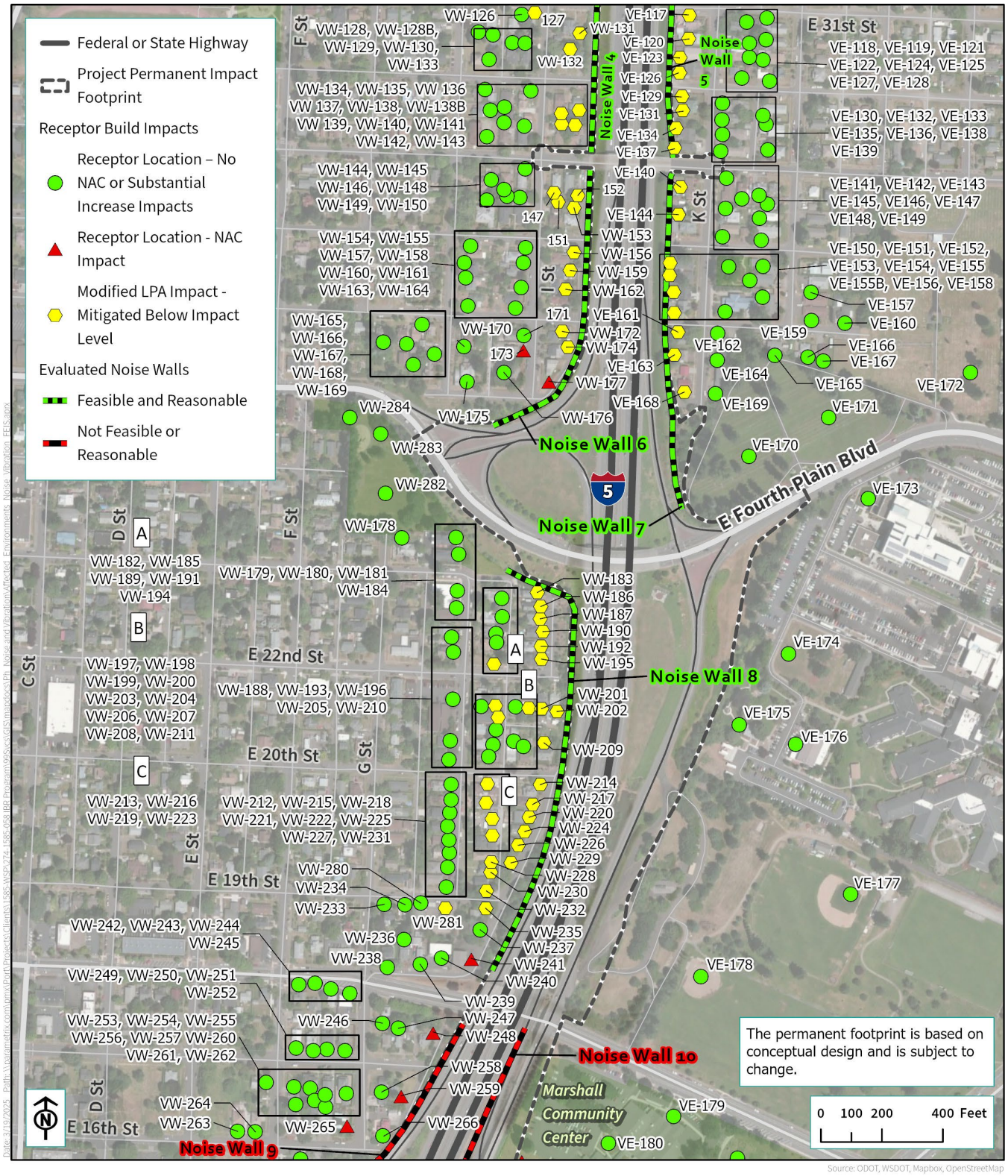
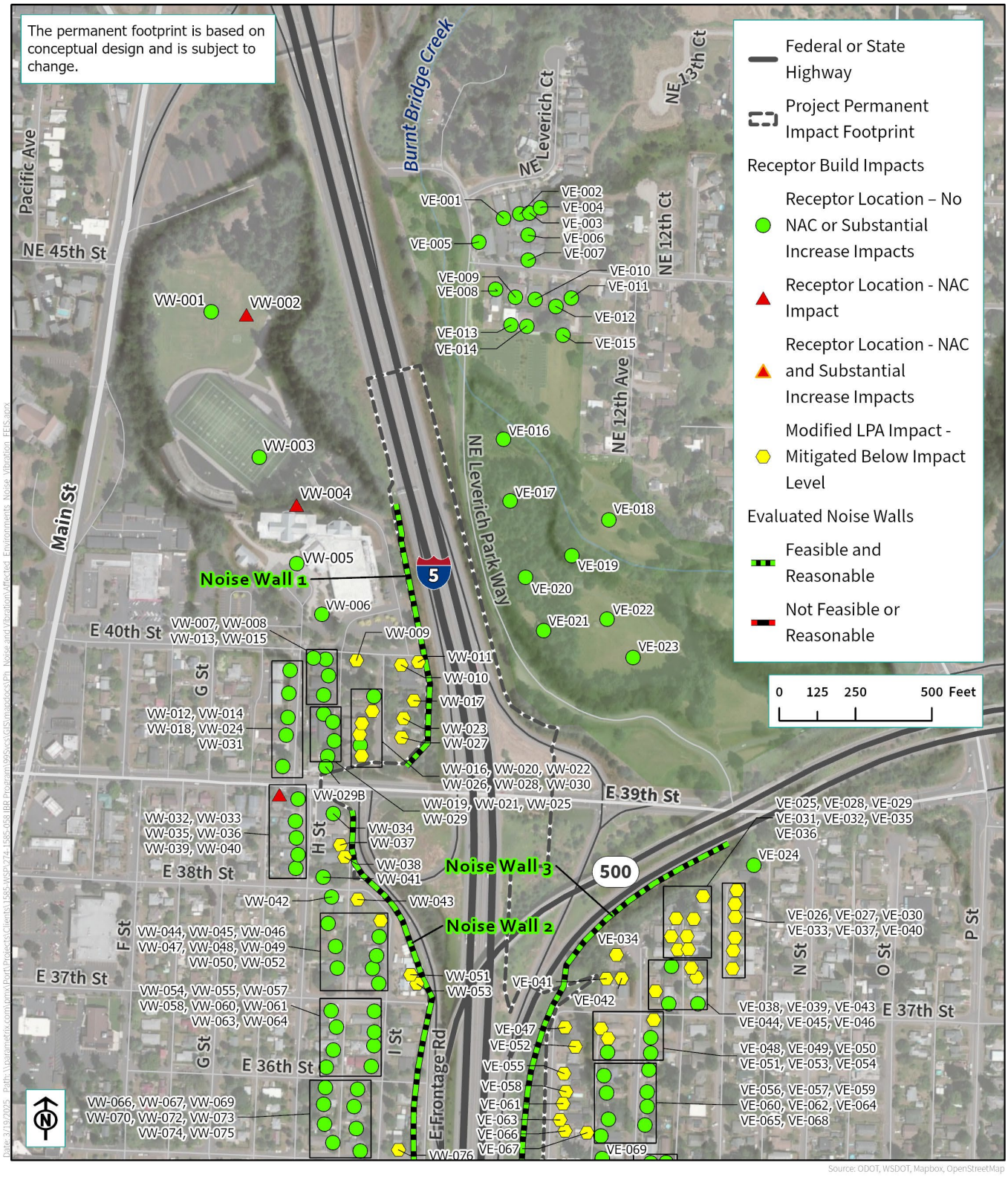


Figure 3.11-20. Modified LPA with Recommended Design Options – 2045 Evaluated Noise Walls – E 30th Street to E 39th Street

Figure 3.11-21. Modified LPA with Recommended Design Options – 2045 Evaluated Noise Walls – E 39th Street to Northern Terminus



Statement of Likelihood

Based on the findings of this analysis, ODOT and WSDOT will further evaluate traffic noise abatement measures in the form of noise walls during the final design of the proposed Modified LPA. The 11 noise wall locations (10 in Washington and 1 in Oregon) determined to be feasible and reasonable (Noise Walls 1, 2, 3, 4, 5, 6, 7, 8, 11A, 12, and 18) will be re-assessed in detail during final design.

The 11 noise walls would mitigate impacts at 82 residences or residential equivalent receiver locations and would benefit an additional 113 residences or residential equivalents. The combined preliminary cost for the 11 recommended noise walls totals approximately $6,808,522. If conditions change substantially during final design of the Modified LPA, the mitigation measure may no longer be feasible and reasonable and, therefore, would not be constructed as part of the Program. A final decision will be made upon the completion of the final design, a cost-estimating process, and the public involvement process, which includes balloting of benefitted receptors.

The IBR Program Team will also continue to evaluate installation of a tall safety barrier or sound barrier along the elevated light-rail transit structure between E 6th Street and E 8th Street in downtown Vancouver to mitigate transit noise impacts at site LRT-1. LRT-1 represents the Normandy Apartments at 316 E 7th Street in downtown Vancouver. A 3- to 4-foot acoustically absorbent wall or 6-foot reflective wall would be effective at reducing transit noise levels at this location by 7 to 10 dBA.

As described in Section 7.8.1 of the Noise and Vibration Technical Report (as listed in Appendix H), there is one location (the Normandy Apartments at 316 E 7th Street in downtown Vancouver) where the Modified LPA would have highway noise impacts and transit noise impacts. Additional information is presented in Section 7.8.1 of the Noise and Vibration Technical Report (as listed in Appendix H) to support the recommendation to include both the highway traffic noise barrier (Noise Wall 12) and a sound barrier along the elevated structure (at site LRT-1). In the area of Noise Wall 12, the I-5 westward shift design option includes property acquisitions at impact locations; therefore, Noise Wall 12 is not included in the I-5 westward shift design option.

Light-Rail Noise and Vibration Mitigation

Light-Rail Noise Mitigation

Table 3.11-13 summarizes the single transit noise impact location, mitigation measures, and future light-rail noise levels after mitigation. Aerial photos of the analysis areas and mitigation are shown in Figure 3.11-22.

Portland Light-Rail Noise Mitigation

No transit noise impacts are predicted in Portland; therefore, no mitigation is needed.

Vancouver Light-Rail Noise Mitigation

- Install tall safety barriers or sound barriers along the elevated structure to mitigate the noise impacts at site LRT-1, which represents the Normandy Apartments located at E 7th Street and E C Street in downtown Vancouver. A 3- to 4-foot acoustically absorbent wall or 6-foot reflective wall would reduce noise levels at this location by 7 to 10 dBA.
- Equip all light-rail track curves with a radius of less than 300 feet with wayside lubricators. After construction of the alignment, during the initial testing, if additional curves are identified with wheel squeal, install wayside track lubricators, as necessary.

Table 3.11-13. Modified LPA with Recommended Design Options - Light-Rail Noise Mitigation Analysis

Receptor [a]	Area Description [b]	Land Use	Number of Units [c]	Existing Noise [d] (dBA)	Light-Rail Noise [e] (dBA)	Project Noise with Mitigation [f] (dBA)	FTA Moderate Impact Criteria [g] (dBA, L_{dn})	Impacts [h]	Mitigation [i]	Residual Impacts [j]
LRT-1	E 7th Street/E C Street	SF	12	83	69	64	66	12	Wall	0

Note: Noise impacts at LRT-1 and related mitigation measures would occur under all design options except the I-5 westward shift design option due to property acquisitions.

a Receivers shown on Figure 3.11-22.
b General description of the area of analysis.
c Number of individual apartments or homes affected.
d Existing noise levels in L_{dn} for category 2 land use, or L_{eq} for category 1 or 3 land uses (see Table 3.11-5 for categories).
e Noise from operation of the light-rail only. This is the noise level used to determine impacts under the FTA criteria.
f Exterior noise level with mitigation.
g FTA impact criteria.
h Number of units adversely affected by project noise.
i Mitigation measures.

dBA = A-weighted decibel; FTA = Federal Transit Administration; L_{dn} = day-night equivalent sound level; SF = single family

Figure 3.11-22. Modified LPA with Recommended Design Options - Light-Rail Noise and Vibration Impacts Post-Mitigation

Light-Rail Vibration Mitigation

Portland Vibration Mitigation

No vibration impacts are predicted in Portland; therefore, no mitigation is needed.

Vancouver Vibration Mitigation

- Use resilient rail fasteners to mitigate vibration impacts along direct fixation track way. Resilient rail fasteners typically reduce vibration levels by 5 VdB, which would not reduce all the predicted vibration levels below the FTA 72 VdB criteria for residential land uses. Receivers LRV-1 and LRV-2, with predicted levels prior to mitigation of 77 VdB and 81 VdB, respectively, would be the only locations where there is still a potential for vibration impact following mitigation.
- Perform additional testing to ensure that the vibration levels at LRV-1 and LRV-2 would be below the 72 VdB and 75 VdB criteria (Figure 3.11-11).

Table 3.11-14 summarizes the vibration levels with and without mitigation. Figure 3.11-22 shows the vibration impacts and proposed mitigation in downtown Vancouver.

Table 3.11-14. Modified LPA with Recommended Design Options - Vibration Mitigation Analysis

Location	Receptor	Area Description [b]	Land Use	FTA Vibration Criteria [c] (VdB)	Vibration Level [d] (VdB)	Vibration Level with Mitigation [e] (VdB)	Number of Potential Impacts with Mitigation [f]
Vancouver	LRV-1	Normandy Apartments	MF	72	77	72	12
	LRV-2	E 8th Street/E C Street	Theater	72	81	76	1 - Theater

Note: Vibration impacts at LRV-1 and LRV-2 would occur under all design options except the I-5 westward shift design option due to property acquisitions.

a Receptors shown on Figure 3.11-22.
b General description of the area of analysis.
c FTA vibration impact criteria.
d Predicted vibration level.
e Predicted vibration level with mitigation.
f Number of individual structures affected.

FTA = Federal Transit Administration; MF = multifamily; SF = single family; VdB = vibration decibels

Table 3.11-15 summarizes the long-term noise and vibration reasonably foreseeable effects that would result from the Modified LPA with the single-level bridge configuration and one auxiliary lane design options. Section 7.9 of the Noise and Vibration Technical Report (as listed in Appendix H) documents that, aside from the differences discussed above for the I-5 westward shift design option, noise levels would be similar for the other design options. Table 3.11-8 summarizes the major differences in impacts and benefits across the Modified LPA's bridge configurations, the one-auxiliary-lane and two-auxiliary-lane design options, and the No-Build Alternative. As detailed in Table 3.11-8, the difference in noise levels between design options result from the distance between the nearest noise-sensitive land uses and the design options, minimal change in traffic noise shielding from roadway alignments to noise-sensitive land uses, and only minor changes in peak hour traffic on local roads between design options.

Table 3.11-15. Comparison of Effects of the Modified LPA with the Single-Level Bridge Configuration and One Auxiliary Lane Design Options without and with Mitigation

Technical Considerations	Modified LPA without Mitigation	Modified LPA with Mitigation
Number of receptors that exceed highway noise thresholds	195	113
Number of receptors with moderate transit noise impact levels	12	0
Number of receptors with severe transit noise impact levels	0	0
Number of receptors with transit vibration impacts	13	13

Temporary Reasonably Foreseeable Effects

Construction noise and vibration BMPs applicable to the Modified LPA with any design option are discussed below.

Construction Noise

Regulatory Requirements

- Comply with ODOT construction noise abatement measures included in ODOT Standard Specification for Construction, § 00290.32 Noise Control (2024) at the time of construction.
- Comply with applicable state and local agency noise ordinance, including ODOT Standard Specification for Construction, § 00290.32 Noise Control (2024) in Vancouver, or project special provisions, for work completed in Washington.
- If a specific noise impact complaint occurs during the construction of the Modified LPA, implement noise mitigation measures outlined in this section as directed by the engineer.

Although WSDOT does not have noise control provisions, WSDOT would voluntarily comply with § 00290.32 for work completed in Washington.

Program-Specific Mitigation

In addition to § 00290.32, ODOT and WSDOT would also implement additional noise abatement methods, including:

- In the event that construction activities exceeds the noise limits in Washington set forth in Table 2-10 of the Noise and Vibration Technical Report (as listed in Appendix H) and local jurisdiction time restrictions, a noise variance will be requested for approval from the local jurisdiction.
- Use equipment complying with pertinent equipment noise standards of the U.S. Environmental Protection Agency (U.S. Environmental Protection Agency 1971).

Construction Vibration

Program-Specific Requirements

WSDOT and ODOT's standard practice is to conduct vibration monitoring to be performed by a competitively selected contractor at structures located in the vicinity of all construction areas, in alignment with the Noise and Vibration Monitoring and Control Plans. WSDOT and ODOT will coordinate with the contractor to conduct continuous vibration monitoring for historic properties constructed with unreinforced masonry structural components within 100 feet of the construction footprint for the duration of Program preconstruction and construction activities, and will require the Noise and Vibration Monitoring Plan to document threshold limits, as well as requirements and protocols to achieve these limits specifically for historic properties (FTA 2018). If structural (such as cracks in the building foundation) or architectural damage (such as cracked plaster, stucco, or tile) to historic properties occurs as a result of Program construction, WSDOT and ODOT, in coordination with FHWA and FTA, will notify DAHP and/or Oregon SHPO, as appropriate, the other Consulting Parties, and the property owner, as appropriate, of the adverse effect on HBE Properties, and then prepare a Treatment Plan to identify and determine any necessary repairs, consistent with the Secretary of the Interior's Standards for the Treatment of Historic Properties.

WSDOT and ODOT will require a noise and vibration monitoring plan to document the details of these requirements and associated protocols, including threshold limits specifically for historic properties. This plan may be prepared by IBR Program staff or by the contractor and be subject to WSDOT and ODOT approval.

ODOT, WSDOT, or the contractor will evaluate and respond to noise complaints in accordance with the Noise and Vibration Monitoring and Control Plans

Additional vibration mitigation measures intended to protect marine life are described in Section 3.16, Ecosystems. Additional mitigation measures related to built historic resources are described in Section 3.8, Cultural Resources.

Noise/Vibration Avoidance, Minimization, and Mitigation Measures Summary

Table 3.11-16 lists temporary avoidance and minimization measures. No long-term avoidance and minimization measures within control of the IBR Program were identified. Table 3.11-17 lists temporary and long-term mitigation measures.

Table 3.11-16. Avoidance and Minimization Measures

Temporary or Long-Term	Impact Type	Avoidance and Minimization Measure
Temporary	Potential structural or architectural damage to historic properties from vibration during construction	WSDOT and ODOT will coordinate with the contractor to conduct continuous vibration monitoring for historic properties constructed with unreinforced masonry structural components within the vicinity of the construction footprint for the duration of Program preconstruction and construction activities, and will require the Noise and Vibration Monitoring Plan to document threshold limits, as well as requirements and protocols to achieve these limits specifically for historic properties (FTA 2018). If structural or architectural damage (such as cracked plaster, stucco, or tile) to historic properties occurs as a result of Program construction, WSDOT and ODOT, in coordination with FHWA and FTA, will notify DAHP and/or Oregon SHPO, as appropriate, the other Consulting Parties, and the property owner, as appropriate, of the adverse effect on HBE Properties, and then prepare a Treatment Plan to identify and determine any necessary repairs, consistent with the Secretary of the Interior's Standards for the Treatment of Historic Properties.
Temporary	Exceedance of noise limits during construction	In the event that construction activities exceed the noise limits in Washington set forth in Table 2-10 of the Noise and Vibration Technical Report and local jurisdiction time restrictions, WSDOT will coordinate with the contractor to request a noise variance for approval from the local jurisdiction.
Temporary	Noise associated with construction equipment and operations, and building equipment	ODOT and WSDOT will coordinate with the contractor to comply with pertinent equipment noise standards of the EPA (EPA 1971).
Temporary	Noise from construction activities in Portland Mainland and Portland/Hayden Island	**Portland Mainland, Portland/Hayden Island –** ODOT will coordinate with the contractor to comply with applicable state and local agency noise ordinances and ODOT Standard Specification for Construction, § 00290.32 Noise Control (2024) in Portland.
Temporary	Noise from construction activities in Vancouver	**Vancouver** – WSDOT will coordinate with the contractor to comply with applicable state and local agency noise ordinance, including ODOT Standard Specification for Construction, § 00290.32 Noise Control (2024) in Vancouver, or project special provisions, for work completed in Washington.

Temporary or Long-Term	Impact Type	Avoidance and Minimization Measure
Temporary	Noise and vibration during construction	ODOT and WSDOT will prepare a detailed construction noise and vibration assessment and construction specifications for construction noise and vibration. The construction noise and vibration assessment will include refined details on the type of equipment planned during construction, location of equipment, equipment usage and duration, and include all associated construction noise and vibration and related sources such as trucks traveling along designated haul routes. This assessment will provide predicted construction levels at all nearby land uses and fragile and historic buildings sensitive to noise and vibration, locations of predicted impacts, and avoidance, minimization, and mitigation recommendations. Data, analysis, and results of this assessment will be used to develop construction specifications for noise and vibration, construction noise and vibration monitoring and control plans to support IBR Program outreach and maintain compliance with ODOT Standard Specification for Construction (00290.32 Noise Control) and WSDOT's voluntary compliance with ODOT 00290.32 for work completed in Washington.

DAHP = Washington State Department of Archaeology and Historic Preservation; EPA = U.S. Environmental Protection Agency; FHWA = Federal Highway Administration; FTA = Federal Transit Administration; IBR = Interstate Bridge Replacement; ODOT = Oregon Department of Transportation; SHPO = State Historic Preservation Office; WSDOT = Washington State Department of Transportation

Table 3.11-17. Mitigation Measures

Temporary or Long-Term	Impact Type	Mitigation Measure
Temporary	Noise complaints during construction	ODOT and WSDOT will evaluate and respond to noise complaints in accordance with the Noise and Vibration Monitoring Plan.
Temporary	Potential construction noise and structural or architectural damage to historic properties from vibration during construction	ODOT and WSDOT will require the contractor to prepare a Noise and Vibration Monitoring Plan to document the details of these requirements and associated protocols, including threshold limits specifically for historic properties.
Temporary	Potential structural or architectural damage from vibration during construction	ODOT and WSDOT will require contractors to perform vibration monitoring at structures located in the vicinity of all construction areas, in accordance with the Noise and Vibration Monitoring Plan.

Temporary or Long-Term	Impact Type	Mitigation Measure
Long-Term	Light-rail track operational noise	**Light-Rail:** ODOT and WSDOT, in coordination with TriMet and C-TRAN, will equip all light-rail track curves with a radius of less than 300 feet with wayside lubricators. After construction of the alignment, during the initial testing, if additional curves are identified with wheel squeal, ODOT and WSDOT, in coordination with TriMet and C-TRAN, will install wayside track lubricators, as necessary.
Long-Term	Light-rail track operational noise at site LRT-1	**I-5/SR 14 Interchange - Light Rail:** WSDOT, in coordination with TriMet and C-TRAN, will install tall traffic safety barriers or sound barriers along the elevated structure to mitigate the noise impacts at site LRT-1, which represents the Normandy Apartments. A 4-foot acoustical absorptive wall or 6-foot reflective wall, extending above the top of rail, will be effective at reducing noise levels at this location by 7 to 10 dBA.
Long-Term	Light-rail operational vibration along direct fixation track way	**I-5/SR 14 Interchange - Light Rail:** WSDOT, in coordination with TriMet and C-TRAN, will use resilient rail fasteners to mitigate vibration impacts located along direct fixation track way. Receivers LRV-1 and LRV-2, with predicted levels of 72 VdB and 76 VdB, respectively, will be the only locations where there is still a potential for vibration impact. WSDOT will coordinate with Tri-Met and C-TRAN to perform additional testing to confirm that the vibration levels at LRV-1 and LRV-2 will be below the 72 VdB and 75 VdB FTA vibration criteria.
Long-Term	Traffic noise at Newport Apartments	**Portland Mainland - Highway:** ODOT will coordinate with the contractor to design and construct Noise Wall 18, if confirmed via poll of benefited receptors.
Long-Term	Traffic noise at residences (Noise Walls 1, 2, 3, 4, 5, 6, 7, and 8) and offices within Fort Vancouver (Noise Wall 11A)	**Vancouver:** WSDOT will coordinate with the contractor and local jurisdictions to conduct community outreach and poll of benefited receptors, design, and reconstruct existing noise walls Noise Wall 1, Noise Wall 2, Noise Wall 3, Noise Wall 4, Noise Wall 5, Noise Wall 6, Noise Wall 7, Noise Wall 8, and Noise Wall 11A. Design and construct Noise Wall 12, if confirmed via poll of benefited receptors.

dBA = A-weighted decibels; FTA = Federal Transit Administration; I-5 = Interstate 5; ODOT = Oregon Department of Transportation; SR = State Route; VdB = vibration decibels; WSDOT = Washington State Department of Transportation